S5 National syntheses of unintentional acute pesticide poisoning (UAPP) by country

Procedure

This chapter is a supplementary part of the manuscript "The global distribution of acute unintentional pesticide poisoning: results of a systematic review". It provides information on the synthesis of data used to arrive at national estimates of UAPP for those 58 countries for which data was extracted from publications. These country synopses specify which publications and data were used for national estimates, highlight specific limitations of the used data and estimation approach.

For each country all included papers were revisited and related to each other and the WHO mortality data. We guided the extrapolation as close as possible by the study population, so for example abstaining from an extrapolation to the whole population when the study base was farmers. Data on the national at-risk or country population were searched for via the internet if not provided by the extracted papers. We looked for population data most closely matching the studied population and study period. If data was not available from other sources, we used data from the World Bank (https://databank.worldbank.org/source/population-estimates-and-projections/Type/TABLE/preview/on#). World Bank provides figures on the overall population and children 0-14 years, as well as the percentage of employment in agriculture and the total employment. We calculated the "farmers/occupational" population by multiplying the share of agriculture by the total employment figures. Because "employment" is for some countries too narrow a definition as it might not include informal farming, estimations of cases are probably too low for some countries. If studies cover the same population/pesticides etc., those more recent or those with less risk-of-bias were preferred, for example those with representative samples and verified diagnoses or pesticides. We reported fatal and non-fatal cases on three types of populations: general (the "all" population category in the spreadsheet of the systematic review), farming/occupational (includes "farmers & workers", "farmers only" and "workers only") and children.

In general, the number of national cases of UAPP was based on the national figures, if provided by the publications, or was estimated by extrapolation of a prevalence ratio to the respective population. For example, if, based on average of surveys, 30 % of farmers are reported to suffer UAPP the total number of non-fatal cases would be derived by multiplying this ratio by the size of the respective population in the country. Country specific approaches are detailed below.

1. Albania

Extracted data

Publications extracted for synthesis: 1.

The study by Sulaj et al. (1) was on aluminum phosphide poisonings only, with total and fatal poisonings reported for Tirana, the capitol of Albania, from 2009-2013. Most cases were suicidal; however, of 140 poisonings (fatal and non-fatal), 8 cases (6%) were found to not be suicides. The source for the population figure of 773,843 was taken from Table 2 of the study, where the authors reported population of Tirana.

Population type	Population of Tirana		Fatal	Non-fatal	Total cases
	Year	**Size**			
General	2009-2013	773,843		NA	1.6
Farming/occupational	NA	NA	NA	NA	NA
Children	NA	NA	NA	NA	NA

Estimation of national figures

Data for the general population of Albania was taken from World Bank data for 2009-2013 and the aluminum phosphide poisonings data for Tirana was extrapolated to the general population of Albania: 1.6 cases per year /773,843= 0.00020676 %, 0.0000020676 * 2,908,246=6

WHO Cause of Death data: no mortality data were available.

Table: National estimate for Albania

Population type	Population		Fatal	Non-fatal	Total cases
	Year	**Size**			
General	2009-2013	2,908,246		NA	6
Farming/occupational	NA	NA	NA	NA	NA
Children	NA	NA	NA	NA	NA

Limitations

The study focused on poisonings and fatalities from a single pesticide, aluminum phosphide. As this pesticide is commonly available and comes in a tablet form, many of the cases were via ingestion and the great majority were due to suicides, so only some of the data reported in this study can be used. The authors' focus was on the fatalities, and the non-fatal cases had no information on whether accidental poisonings were included.

The study also focused on a limited area in Albania, a single university centre in the capitol city of Tirana. Following extensive discussion, we decided not to include these data in our estimates because the data were from one city, for one pesticide that has very narrow and specific uses, and we agreed that it did not adequately represent the general use of or exposure to pesticides in the country.

2. Argentina

Extracted data

Publications extracted for synthesis: 1.

The study by Butinof et al. 2015 (2) was available for Argentina. It related to agricultural workers, i.e. terrestrial pesticide applicators, in the province of Córdoba. From a "universe" of 3,500 individuals a sample of 880 applicators with direct exposure to pesticides was identified for further analysis. Based on self-reported symptoms, the highest prevalence (47.4%) was for "irritation", a term that – according to the authors – subsumed "irritation of skin, eyes, nausea, vomiting, and respiratory disorders".

Estimation of national figures

WHO Cause of Death data: available, see following table

Table: National estimates for Argentina

Population type	**Population**		**Fatal**	**Non-fatal**	**Total cases**
	Year	**size**			
General	2011-2015	42,583,565 [1]	5.6 [2]		
Farming/occupational	2007-2010	194,029 [1]		91,969.7	
Farming/occupational	2011-2015	104,522 [1]	0.4 [2]		
years combined	2007-2015	149,275	0.4	70,756 [3]	70756.4
Children	2011-2015	10,827,710 [1]	0.6 [2]		

[1] average, World Bank data
[2] WHO
[3] calculated 47.4% by combined population

Limitations

Survey data (Butinof et al. 2015), based on 880 cases of directly exposed pesticide applicators, but the "farming/occupational" population may contain a number of farm workers not directly exposed.

3. Australia

Extracted data

Publications extracted for synthesis: 1

Ling et al 2018 (3)

- A retrospective case series of the Poison Centre for the State of Victoria
- Period of study = June 2005 – December 2013
- Occupational – but does not specify if it is farmers, workers, urban pest control operators and/or others using pesticides in an occupational setting
- Morbidity = 70/year

WHO Cause of Death data: On average, 1.8 fatal poisonings per year were reported in the WHO Cause of Death database for the general population of Australia (2011-2015).

Estimation of national figures

The population of Victoria in 2019 was estimated to be 6,566,200 at 31st March 2019, according to the Australia Bureau of Statistics (ABS), 38.5% of the total Australian population of 25,287,400. As the ABS did not provide population figures for all years and FAOSTAT did, but did not provide population figures for Victoria at all, a combination of data sources was used. Where that data was available for particular years from both sources, it exactly matched.

ABS figures were used to calculate the % of Australian population that lives in Victoria and this % was then applied to the FAOSTAT annual population for the relevant years to arrive at a projected annual reported occupational pesticide poisoning for the whole of Australia over the period 2005-2013.

Year	**Population Australia (FAOSTAT)**	**Population Victoria (ABS)**	**Total Cases Victoria**	**Projected cases Australia**
2005	20,178,540			
2006	20,526,303			
2007	20,916,340			
2008	21,332,282			
2009	21,750,851			
2010	22,154,679			
2011	22,538,001			
2012	22,903,948			
2013	23,254,913			
average	*21,728,429*	*5,642,873*	*70*	*270*

Table 1: National estimate for Australia

Population type	**Years**	**Population size**	**Fatal**	**Non-fatal**	**Total cases**
General	2011-2015	23,116,664	1.8		1.8
Farming/ occupational	2005- 2013	349,697	0	270	270
Children	2011-2015	4,369,711	0		

Limitations

There is only one publication, for only one state. It provides occupational data, but does not specify if it is for farmers, workers, urban pest control operators and/or others using pesticides in an occupational setting. It reports only on cases reported to the Poisons Centre and so many cases not reported are missed.

The estimates rely on the assumption that the relationship of the population of Victoria to the total Australia population is the same as the workers population of Victoria to total Australia, and on the assumption that the ratio of farmer & workers to total population in 2016 was the same for the study period.

4. Bangladesh

Extracted data

Publications extracted for synthesis: 6

Akhter et al. 2016 (4)

- Period of study = 2016
- Kaligonj and Jhenidah sadar upazilas in the District of Jhenidah
- Sample = 80 farmers, representative, growing mainly vegetable crops.
- Morbidity = 84% (symptom with highest prevalence)

Akter et al. 2018 (5)

- Period of study = 2015-2016
- Palbandha and Char Goalini unions in Islampur upazila in the District of Jamalpur
- Sample = 101 vegetable farmers, representative, but all male
- Morbidity = 60.4% (for symptom with highest prevalence)

Dey 2010 (6)

- Period of study = presumed to be 2008
- Three sub-districts, not identified
- Sample = 180 vegetable farmers, representative, randomly selected from three different sites with high, medium, low cropping intensities
- Morbidity = 29.8% (for symptom with highest prevalence)

Miah et al. 2014 (7)

- Period of study = 2012
- Bharella, Mokam and Rajapur unions of Burichong Upazila
- Representative sample of 120 farmers, selected for high, medium, and low level of vegetable production
- Morbidity = 55% (for symptom with highest prevalence)

Rengam et al. 2018 (8)

- Period of study = 2017
- Study area = the five sub-districts of Satkhira district
- 534 farmers (77%) and workers, including 40 women, rice and vegetable growers
- Morbidity = 330 cases based on symptom with highest prevalence = 62%

Tomenson and Matthews 2009 (9)

- Period of study = 2006
- No details of where, or what kind of farmers, or how they were selected
- Representative sample of 258 farmers & workers
- Morbidity = 110 cases in past 2 months = 42.64%

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Five of the six studies covered vegetable growing and one covered rice, the sixth did not identify crops cultivated. Sample seizes ranged from 80 to 534 and morbidity ranged from 42.6 to 84%. Given the different timeframes and sample sizes, there is no apparent way to weight the outcomes and so a simple average is taken for the years 2006 to 2017.

Year	Sample	Morbidity	Study	Symptom range
2006		42.64%	Tomenson & Matthews 2009	all symptoms
2008	180	29.8%	Dey 2010	highest symptom
2012	120	55%	Miah et al. 2014	highest symptom
2015-16	101	60.4%	Akhter et al. 2018	highest symptom
2016	80	84%	Akhter et al. 2016	highest symptom
2017	534	62%	Rengam et al. 2018	highest symptom
average		*55.64%*		

Table: National estimates for Bangladesh

Population type	Year (average)	Population size	Fatal	Non-fatal (estimated)	Total cases
General	2006-16	153,176,326			
Farming/occupational	2006-16	26,463,451		14,724,264	
Children	2006-16	48,532,297			

Limitations

All but one study reported only the highest symptom prevalence, not total symptom incidence, so the result is likely to be a lower limit.

5. Bolivia

Extracted data

Publications extracted for synthesis: 1.

Jørs et al. 2014 (10) analysed the effect of "Farmer Field Schools" (FFS) on the absence of self-reported pesticide intoxication symptoms in 22 FFS-farmers and 47 "neighbor" farmers who had no FFS-participation. The prevalence of self-reported symptoms could be inferred from the rates of absence of symptoms, demonstrated in Table 2 of that publication, which was not significantly different between FFS-farmers and neighbour-farmers (p-value of χ^2-test = 0.43). Therefore, here, the prevalence of symptoms has been collated for the two subgroups: 24/69 = 34.8%.

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Table: National estimate for Bolivia

Population type	Population		Fatal	Non-fatal	Total cases
	Year	size			
Farming/occupational	2009	1,333,541*		464,072	

Limitations

The following limitations apply to the data presented by Jørs et al. 2014: small number of participants; self-reported symptoms may not accurately reflect the real prevalence of symptoms. The figures are derived from a study in four municipalities within the La Paz county.

6. Brazil

Extracted data

Publications extracted for synthesis: 7. At the national level, Magalhães and Caldas (11) analyzed the occurrence of fatal pesticide intoxications in the general population, and Santana et al. (12) that in farmers. De Albuquerque et al. (13) dealt with both morbidity and mortality of the general population at the district level. Further studies of morbidity induced by pesticides were performed at the district level for farmers/agricultural workers (Cargnin et al. (14), Faria et al. (15), Lermen et al. (16)), and children (De Souza Campos et al. (17)).

Magalhães and Caldas (2018) compared Federal District data for fatal poisonings of 4 different databases and included national data from the *Sistema de Informação de Mortalidade* (SIM). SIM data which employed the ICD-10 classification from 2009 to 2013 were used here. A total of 246 fatal cases of accidental poisoning by and exposure to pesticides (X48) correspond to 49.2 cases annually.

Santana et al. (2013) also used the SIM database described above and extracted the mortality data classified as X48 according to ICD-10 for farm workers from 2000 to 2009. Although the data of Magalhães and Caldas (2018) mentioned above where more recent, Santana et al (2013) provide data for the subgroup of agricultural workers with mortality rates (per 100,000 persons) of 0.37 for 2006/2007 and 0.39 for 2008/2009.

De Albuquerque et al. (2015) performed a cross-sectional study in Pernambuco state from 2008 to 2012 and compared the contribution of three different databases (SINAN, CEATOX and SIM) to the characterization of pesticide poisoning. The study provides the total number of fatal cases for the five-year period which was highest in SIM (n=552), but this number includes categories other than X48 (e.g. X68 [self-poisoning] etc.). Therefore, the data presented in this paper cannot be used.

Cargnin et al. (2017) surveyed the morbidity (intoxication symptoms) in a sample of 100 tobacco growers (97 of them confirmed using pesticides) in the federal state Rio Grande do Sul. The interviews were performed in January 2012. Twenty persons reported intoxication symptoms resulting in a morbidity rate of 20.6%. The notion of 14 cases of vomiting in the text, described as

22.6% appears to be inconsistent. In addition, while the interviews were carried out in January 2012 the authors claimed to have made a survey in 2012/2013. The special subgroup of agricultural workers (tobacco growers) and the inconsistencies are limitations for this study.

Faria et al. (2009) conducted a survey of intoxication symptoms in 290 fruit farmers in the municipality of Bento-Gonçalves (Southern Brazil) in 2006. Of those, 3.8% reported occurrences of pesticide intoxication during a 12 months period.

Lermen et al. (2018) focused on 73 citrus fruit growers in a region the federal state of Rio Grande do Sul. The study also included a non-exposed control group 30 persons. Because the ethics protocol number is 2 072.009.2014, it can be assumed that the study was carried out in 2014 or 2015. The most prevalent symptom of exposed persons was headache and was reported in 25 of 73 persons (35%).

De Souza Campos et al. (2017) reported 737 cases of intoxications by “legally and illegally commercialized household sanitizers” in children under 7 years of age from a regional database (CIATOX of the state of São Paulo) from a 12-month period (October 2013 to September 2014). These CIATOX data referred of the region Campinas within the state São Paulo encompassing 90 municipalities and an estimated population of 6.5 million inhabitants. However, the number or percentage of children was not given. During this period 122 cases of poisoning by “insecticides and rodenticides” were recorded, one of them was fatal. These data were not used, because the population size of children under 7 years of the Campinas region is unknown and for the fatal case it cannot be excluded or may even be likely that it is contained in the WHO statistics.

Estimation of national figures

For fatal poisonings, WHO Cause of Death data from 2011-2015 were used.

The average prevalence of non-fatal intoxications is the result of three different studies (Cargnin et al. 2017, Faria et al. 2009, Lermen et al. 2018). Although the prevalence was different for all studies (see above), the one in Faria et al. (2009) was particularly low (3.8%). While several reasons for these differences exist (different crops grown and, therefore, probably different pesticides used, and different methods/questionnaires used for the interviews of farmers), it should be noted that the use of personal protective equipment (PPE) was exceptionally high in the Faria et al. 2009 study: use of boots, hat, protection clothes gloves **and** (!) pesticide masks by approximately 95% of the respondents. In contrast, PPE use in the other two studies was clearly lower. Because in Brazil provision of PPE is mandatory by law (as described in Cargnin et al. 2019), it is difficult to assess what degree of PPE use is “representative”. Therefore all three studies were used for calculating the average.

Table: National estimates for Brazil

Population Type	Population		Fatal	Non-fatal	Total cases
	Year	size			
General	2011-2015	202,366,309*	47		
Farming/occupational	2006,2011-2015	11,819,651	4	2,340,290	2,340,294
Children	2011-2015	47,424,655	6		

*average, Worldbank data (Excel file)

Limitations

Cargnin et al. (2017) and Lermen et al. (2018) describe intoxications of relatively small samples (100 and 73 persons, respectively). Moreover, these farmers and those in Faria et al. 2009 were mainly cultivating specific crops (tobacco, fruits, citrus fruits, respectively), which may or may not reflect wider pesticide use and exposure patterns.

For De Souza Campos (2017), it was not possible to extrapolate these data, because the primary data (population data for this specific age group, 0-6 years, in the particular region, São Paulo state, were not available).

7. Burkina Faso

Extracted data

Publications extracted for synthesis: 2.

Both studies were surveys of farmers and/or agricultural workers.

Toe et al. (18) surveyed workers using insecticides in the Sahelian region of Burkina Faso during July-August 2009 and found 85% reporting symptoms after spraying insecticides, based on the most common symptom of headache.

Toe et al. (19) surveyed mostly farmers and the types of pesticides they used, in three major agricultural areas for cotton production—Hauts-Bassins, Cascades, and Boucle de Mouhoun, in June-July 2010. This was a representative sample of farmers for those populations. 82.66% reported having experienced at least one of a list of symptoms during or just after spraying.

The prevalence for Toe et al. (2012) and Toe et al. (2013), were 85.0% and 82.66%, respectively. The average prevalence, based on the most prevalent symptoms of pesticide poisoning reported in the study was 83.83%.

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Burkina Faso agricultural employment data are from the World Bank table: 3,556,616;

so: 0.8383 * 3,556,616 = 2,981,511

Table: National estimates for Burkina Faso

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General	NA	NA	NA	NA	NA
Farming/occupational	2009-2010	3,556,616	NA	2,981,511	2,981,511.19
Children	NA	NA	NA	NA	NA

Limitations

Some of the demographic data were not from the year that the study was conducted. We do not have access to data on the rest of the population. In Toe et al. 2013, healthcare centres were surveyed, and pesticide poisoning data were reported. However, these data could not be used in estimates due to an undefined catchment area for the healthcare centres.

The survey data in Toe et al. 2013 were based on a representative sample of farmers from major cotton growing regions and Toe et al. 2012 was a cross-sectional study of insecticide applicators from the Sahelian region of Burkina Faso. The latter study was based on availability and willingness of the participants to be surveyed, which may not be as representative a sample as Toe et al. 2013, where the farmers were randomly sampled to determine who was surveyed.

8. Cambodia

Extracted data

Publications extracted for synthesis: 3.

Jensen et al. (20)

- Period of study = 2006
- Representative sample = 89 aquatic farmers from the villages of Thnout Chrum and Kba Tumnub at Boeung Cheung Ek Lake, Phnom Penh, cultivating water spinach, grown in rows secured by a string between two poles to prevent the crops from floating away. This sample was all the farmers from the 2 villages. Pesticides are regularly applied.
- Morbidity = 88% with symptoms of UAPP in relation to spraying in the preceding month.
- Data ok to extrapolate to other aquatic farmers it is unknown whether it is representative of terrestrial farmers.

FAO (21)

- This is a complex study involving an FAO training programme. The report identified impacts of the IPM training, including comparing UAPP after the training in IPM (2010) with a baseline study before the training (2008), and also involved control groups of farmers not exposed to IPM training as well as those exposed to it indirectly. Only farmers for whom both baseline and impact data were available were included in the analysis, hence the sample size was 250 (90 +74 +86). However, only the 2008 data could be extracted because of incomplete data from 2010.

Area	**2008**			**2010**		
	IPM-PRR	**Exposed to IPM**	**Control**	**IPM-PRR**	**Exposed to IPM**	**Control**
Battambang	50	50	50	48	35	44
Prey Veng	50	50	50	42	39	42
Total	100	100	100	90	74	86

- The report states that in addition to the 58,716 farmers directly trained in FAO-supported Farmer Field Schools (FFS), thousands of additional farmers have benefited from FFS, so the results are relevant for a significant portion of Cambodian farmers and are ok to extrapolate
- Sample = 250 respondents in six FAO project and four control villages in two provinces (Battamabang and Prey Veng) on opposite sides of the country, both major rice and vegetable growing areas. [127 respondents were interviewed twice]
- The report states that usually only serious pesticide poisoning cases or suicide attempts are reported
- Baseline study: in Battambang, 67% of farmers reported experiencing signs and symptoms, while in Prey Veng this figure was 73%
- The 2010 study shows a 13% decrease in UAPP in Battambang and a 17% decrease in Prey Veng as compared with the controls but does not give the actual data
- The UAPP has been averaged across both provinces, all groups
- Morbidity = 70%

Schreinemachers et al. (22)

- Period of study = 2015
- Representative sample from main production area and main production season = 300 farmers growing yard-long bean and leaf mustard across 6 districts, across 22 villages
- Morbidity = 54% for highest symptom incidence
- Authors noted that across three SE Asian countries pesticide use was 42% less when a woman was in charge of pest management

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

The 3 studies cover aquatic vegetable growing, terrestrial vegetable growing and rice. There are 2 options:

i) Average all results across all crops, which results in 70.67%.

ii) Omit the aquatic vegetable growing because it is a specific situation, is earlier and a much smaller sample size. It is not known how big a portion of Cambodian agriculture involves aquatic spinach growing (FAO does not include it in crop data), although it is reported to be a major crop for Phnom Penh (Holm et al 2010). However, this cultivation is fed by both domestic and industrial sewerage and so it is quite possible that some of the health impacts experienced by farmers arise from the contaminated water sources.

Option ii) was the preferred option, but the impacts of the aquatic vegetable growing should be noted.

Year	**Sample**	**Farming type**	**Morbidity**	**Study**	**Symptom range**
2006	89	Aquatic veg.	88%	Jensen et al. 2011	all symptoms
2008, 2010	250	Veg and rice	70%	FAO 2013	all symptoms
2015	300	2 veg only	54%	Schreinemachers et al. 2017	all symptoms
average		*Option ii)*	*62%*		

Table: National estimates for Cambodia

Population type	**Year**	**Population size**	**Fatal**	**Non-fatal**	**Total cases**
Farming/occupational	2008-15	3,667,204	NA	2,273,666	2,273,666

Limitations

Only two studies were regarded as representative, with an additional one on aquatic vegetable cultivation with high prevalence of UAPP, but these data were not used for the national estimate due to a lack of information as to the prevalence of such cultivation. There were no data on mortality.

Source:

Holm PE, Marcussen H, Dalsgaard A, 2010. Fate and risks of potentially toxic elements in wastewater-fed food production systems— the examples of Cambodia and Vietnam. Irrig Drainage Syst. 2010 24:127–142 DOI 10.1007/s10795-009-9086-6.

9. Cameroon

Extracted data

Publications extracted for synthesis: 5.

Achancho and Nsobinenyui (23) was a simple/not reported sample of farmers from Munyenge, SW Cameroon, data were self-reported symptoms, surveyed October to December 2017, with 62 of 296 reporting the most prevalent symptom of headache after spraying pesticides.

Assokeng et al. (24) was a representative sample of market gardeners (farmers) from a market in Ngaoundere, a northern city of Cameroon. 60 were interviewed April 10-August 15 in 2013, with 18 self-reporting headache as the most prevalent symptom when handling pesticides.

Pouokam et al. (25) reported on a representative sample from farmers' groups. 395 reported ever having experienced a pesticide poisoning situation, surveyed in 2016, with the % of farmers reported as 40.3% (159 people).

Tandi et al. (26): the period of study was September 2012 to November 2013. Tomato farmers from Buea municipality, SW region of Cameroon only were surveyed, 79 of 93 reporting most prevalent symptom of weakness after spraying pesticides.

Tomenson and Matthews (9) is a survey of pesticide applicators and farmers commissioned by Syngenta Crop Protection among 2,431 users in eight countries. The sample was representative, with n=261 for Cameroon, giving self-reported symptoms for poisoning and of those, 154 reporting minor-to-serious incidents.

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

World Bank data for the population employed in agriculture were available for Cameroon through 2016. The population data from the years that data were collected in the studies was averaged.

Study	Year	Size	% farmers poisoned/yr
Achancho et al.	2016	6,055,412	21
Assokeng et al.	2013	5,661,619	39.09
Pouokam et al.	2016	Listed above for Achancho paper	40.3
Tandi et al.	2012-2013	2012: 5,571,169; 2013: listed for Assokeng	84.9
Tomenson & Matthews	2006	4,788,083	59.00383140

The average % of farmers poisoned for all 5 studies = 0.488587663

Reported in the table below: 1) the average number of people working in agriculture for all the years where the data were reported (2006, 2012-2013,2016, and 2017) and 2) the number of people poisoned calculated using the average of the % poisoned from the 5 studies.

Table: National estimates for Cameroon

Population type	Population		Fatal	Non-fatal	Total cases
	Year	**Size**			
General	NA	NA	NA	NA	NA
Farming/occupational	2006,2012-2013,2016	5,519,071	NA	2,696,549	
Children	NA	NA	NA	NA	NA

Limitations

These data were based on self-reported surveys or interviews of farmers. The % of the population farming was not found for each year that data were found, but an approximation was used from FAOSTAT data from 2005 (used for the study reporting data collected 2006) and 2016 (used for the data collected in 2012-2013, 2016, and 2017). So these figures don't necessarily correspond to the exact year the data were collected. The populations of farmers were sometimes described as representative, and in addition the studies surveyed or recruited from certain groups of farmers, thus pesticide use may have varied depending on the type of farmer surveyed. In addition, survey questions varied, with some studies asking questions about symptoms, and others asking questions about whether users had experienced a pesticide poisoning incident.

10. Canada

Extracted data

Publications extracted for synthesis: 1.

Boyd (27) was the only eligible paper and reported poisonings data for each province. The average poisoning rate by pesticides (unintentional exposures, including children) in Canada in this report was 18 per 100,000 of the population (0.018%) in 2006. According to the report, deaths from pesticides are extremely rare in Canada and the report did not give any data on pesticide deaths. The Boyd paper noted that children under age 6 represented 46.5% of the poisonings, so we also report the statistic for children under 6 for the national estimates.

Estimation of national figures

Two deaths were reported by Canada in the WHO Cause of Death database over a 5-year period. Averaged over five years, this results in 0.4 deaths per year from 2009-2013.

The calculation for the general population 18 per 100,000:

General population 2006: 0.00018* 32,570,505= 5,862

Children under age 6: 0.465 * 5,862 = 2,725.83

Table: National estimates for Canada

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General	2006	32,570,505		5,862	
	2009-2013	34,375,908	0.4		
years combined	2006, 2009-2013	33,473,207	0.4	5,862	5862.4
Farming/occupational	2009-2013	396,811	0	NA	NA
Children	2006, 2009-2013	2,086,844	0	2725.83	2725.83

Limitations

The reporting systems relied on for Boyd 2007 were varied in time range depending on the province. Data gaps for different provinces meant that the time frame for pesticide poisonings reports could not be collected solely in a single year for the entire country. The data were taken from information reported by provinces, health centres, and poisoning centres in Canada from various time frames within the years 2002-2006. However, much of the data reported in the report either spanned 2005 to 2006 or were from 2006. It was possible to separate out the data for individual provinces, but basing a national estimate on these data for extrapolation would not have resulted in greater accuracy than taking the estimate made by the report for the entire country. The data for Manitoba and the Yukon, Nunavut, and Northwest territories could not be obtained, so estimates were made based on the average per capita poisonings for Canada. The report indicated that, if anything, it was likely that the data reported was an underestimation of pesticide poisoning in Canada.

11. Chile

Extracted data

Number of publications extracted for synthesis: 2.

Munoz-Quezada et al. (28) surveyed agricultural and non-ag workers on organophosphate pesticide use. The workers were a representative sample from Maule, Chile, an area with a large rural population and has high rates of OP poisoning. Responses were self-reported from a survey and for our purposes, only agricultural worker data was extracted and the most prevalent symptom used to estimate poisonings for our purposes was headache. The year 2014 was mentioned in association with knowledge of what pesticides were used in 2014, however, it was not clear what year the data were collected, so an assumption was made that the data were fairly recent for this study (we assumed 2013-2016 population data and averaged the population from those years for use in the estimate). The authors also referenced a 2014 study that they had done, presumably with the same population of workers. The estimate for agricultural workers was 35% poisoned by OP use.

Ramirez-Santana et al. (29) reported data from a 3 year period (January 2009 to December 2011) based on reported cases at the Ministry of Health from the Coquimbo area in Chile. The study reported that 0.13% of agricultural workers were reported poisoned during that time period (57 of 45,000).

Estimation of national figures

World Bank data on the population of farmers and workers from the years 2009-2011 and 2013-2016 (assumption for the years covered by the Munoz-Quezada study) were used for this estimate. For the farming population, an average prevalence of 17.63% pesticide poisoning was used for an estimate.

WHO Cause of Death data: available from 2011-2015 as the most recent years. The total fatalities were 45, with an average of 9 fatalities per year from the general adult population.

0.1763* 784,044 =138,226.968

Table: National estimates for Chile

Population type	Population		Fatal	Non-fatal	Total cases
	Year	**Size**			
General	2011-2015	17,460,513	9	NA	
Farming/occupational	2009-2011, 2013-2016	784,044	NA	138,226	
Children	NA	NA	NA	NA	NA

Limitations

The Coquimbo area of Chile may not be representative of the entire country's agriculture, so extrapolating from the cases of APP reported in Ramirez-Santana et al. 2014 clearly has limitations. The same can be said of extrapolating from the Munoz-Quezada et al. 2017 study, which surveyed organophosphate pesticide use among workers, but only reported on the most prevalent symptom not 'any' symptom.

12. China

Extracted data

Publications extracted for synthesis: 6.

Wang et al. (30)

- Period of study = 2006-2015
- Jiangsu province – the pesticide poisoning data were acquired by means of a routine surveillance system by the Jiangsu Centre for Disease Prevention and Control
- Morbidity = 401 (accidental) + 924 (occupational) cases per year = 1325
- Mortality = 8 cases (accidental) + 4 (occupational) per year = 12
- Data ok to extrapolate

Wang et al. (31)

- Period of study = 2006-2017

- Jiangsu province, children only, cases reported to Jiangsu Centre for Disease Prevention and Control
- At the age of 7, oral intake of pesticides to commit suicide began to appear, and it increased significantly after the age of 10
- Morbidity (unintentional) = 55 cases per year = 0.00049433%
- Data ok to extrapolate

Zhang et al. (32)
- Period of study = 2000-2010
- Heilongjiang province, population = 38,000,000 in 2011
- Homicide = 4 cases per year
- Data ok to extrapolate

Zhang et al. (33)
- Period of study = 2006-2010
- Zhejiang province; data were obtained from the Occupational Disease Surveillance and Reporting Systems, which covers hospitals, community healthcare clinics, rural clinics
- Morbidity = 478.4 (accidental) + 804.2 (occupational) cases per year = 1282.6
- Mortality =11.2 cases (accidental) + 5.4 (occupational) per year = 16.6
- Data ok to extrapolate

Zhang et al. (34)
- Period of study = 2009-11
- Jiangsu province
- Study reports “figures suggest 53,300-123,000 Chinese people are poisoned every year”
- Representative sample = 1490 workers
- Morbidity = 121 = 8.12% - experienced symptoms in last 12 months
- Data ok to extrapolate

Zhang et al. (35)
- Period of study = 2009
- Representative sample = 910 farmers and workers from 2 villages, 1 low (Subei) and 1 high income (Sunan) in Jiangsu province
- Note: authors required 2 or more symptoms to be indicative of APP and as a result concluded 8% UAPP; had also anticipated 10% was the likely poisoning rate
- Morbidity = 13.63% for any single symptom within 24 hrs of applying pesticides, ever
- Data ok to extrapolate

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Synthesis of extracted data

Study	**Year**	**Sample**	**Population**	**Morbi-dity**	**Morta-lity**	**Homi-cide**	**Sym-ptom range**	**Time covered**	**Extra-pol ated**
Wang et al. 2017	2006-15	Jiangsu	general	401	8		any	per annum	+
"	"	"	occupational	924	4			"	
Wang et al 20018	2006-17	Jiangsu	children	55	?		any	per annum	+
Zhang et al 2013(a)	2000-10	Heilong jiang	general			4		per annum	+
Zhang et al 2013(b)	2006-10	Zhejian g	general	478.4	11.2		any	per annum	+
	"	"	occupational	804.2	5.4			"	
Zhang et al 2016	2009-11	Jiangsu	1490 workers	8.12%			any	Ever?	+
Zhang et al 2011	2009	Jiangsu	910 farmers & workers	13.63 %					
	average								

The following population figures were obtained from Wikipedia:[1]

	Population	**% of China**
China	1,339,724,852	100%
Jiangsu	78,659,903	5.9 %
Heilongjiang	38,312,224	2.9%
Zhejiang	54,426,891	4.1 %

Occupational estimates

Study	Jiangsu - morbidity	Jiangsu mortality	% morbidity	Jiangsu % of China	China farming population	China morbidity	China mortality
				5.9%	187,787,296		
Wang et al. 2017	924	4				1574	7
Zhang et al 2013b			8.12%				
Zhang e al 2011			13.63%				
Average			**10.88%**		**187,787,296**	**20,431,256**	**7**

The Shen study results are so vastly different from the two Zhang studies for morbidity, and include only cases reported to the CDC, that it is not included in the above estimation.

[1] https://en.wikipedia.org/wiki/List_of_Chinese_administrative_divisions_by_population

General population

Study	Sample	Poisoning	Morbid.	Mortality	China morbidity	China mortality
Wang et al. 2017	Jiangsu	accidental	401	8	6,796.6	135.6
Zhang et al 2013(b)	Zhejiang	accidental	478.4	11.2	11,668.3	273.2
Average					*9,232.5*	*204.4*

Table: National estimates for China

Population type	Year	Population size	Fatal	Homicidal	Non-fatal	Total cases
General	2006-2016	1,344,444,091	204.4	14	9,232.5	9,436.9
Farming/occupational	2006-2016	187,787,296	68	NA	20,431,256	20,431,324
Children	2015-2016	242,346,459	NA	NA	969.4	

Limitations

Regional statistics show only reported cases and hence are significantly less than studies on occupational APP and do not reflect cases not reported.

13. Colombia

Extracted data

Publications extracted for synthesis: 4.

Chaparro-Narvaez and Castaneda-Orjuela (36) used national pesticide report records of fatalities from pesticide exposure for homicides and accidental poisonings (classified by ICD-10 codes). The Chaparro-Narvaez 2015 paper relied on a national registry, and only reported fatal pesticide poisonings. These data were excluded from the national estimates because the WHO Cause of Death data were more recent.

Tomenson and Mathews (9) is an industry led paper, with the survey of pesticide applicators and farmers commissioned by Syngenta Crop Protection among 2,431 users in eight countries. The sample was representative, with n=251 giving self-reported symptoms data on poisoning and of those, 159 reporting minor-to-serious incidents.

Varona et al. (37) conducted a survey of farmers and workers (simple sample/not stated) working in rice cultivation in Guamo-Espinal area in Tolima, Colombia in 2014-2015, with 292 of 339 self-reported symptoms or signs of poisoning after direct contact with pesticides.

Uribe et al. (38) surveyed a simple sample/not stated group of workers from la Merced-Caldas engaged in tomato planting who had used OPs, carbamates and OC pesticides in the last 6 months in 2009-2010, with 74 of 132 reporting having presented some symptoms at the time they were using pesticides.

Estimation of national figures

Tomenson and Mathews reported 63.3466135% poisoned of a representative sample of farmers and workers; the data were collected in 2006. Varona et al. 2016 reported 86.13569322% APP of farmers and workers in rice cultivation (2014-2015). Uribe et al. 2012 reported 56% of workers planting tomatoes having experienced poisoning symptoms 2009-2010. Average % farmers/workers poisoned from the 3 studies was 68.5%:

0.685* 3,689,694= 2,527,440

The WHO Cause of Death data were as follows for 2011-2015: 16.4 fatalities per year, child fatalities were 4.4 per year, farmer fatalities were 1.8 per year. World Bank data on the child population of Colombia from 2011-2015 were used.

Table: National estimates for Colombia

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General	2011-2015	47,330,342	16.4	NA	16.4
Farming/occupational	2006	3,521,629			
	2009-2010	3,794,990			
	2014-2015	3,752,463			
years combined	2006, 2009-2010, 2014-2015	3,689,694		2,527,440	
	2011-2015	3,807,441	1.8		2,527,441.8
Children	2011-2015	11,894,866	4.4	NA	4.4

Limitations

Three studies surveyed farmers and workers, Varona et al. 2016 surveyed rice growers and Uribe et al. 2012 surveyed tomato growers who were using OP or OC insecticides, and Tomenson and Matthews 2009 surveyed users of pesticides. The focus on tomato or rice growers is not necessarily representative of all of the farmers and workers in Colombia.

14. Costa Rica

Extracted data

Publications extracted for synthesis: 1.

Tomenson and Matthews (9) with the survey of pesticide applicators and farmers commissioned by Syngenta Crop Protection among 2,431 users in eight countries. The sample was representative, with an n=250 giving self-reported symptoms data on poisoning and of those, 80 reporting minor to serious incidents.

Population data were from World Bank.

Estimation of national figures

Tomenson and Matthews 2009 reported 32% of users experiencing poisoning:

0.32* 259,564

WHO Cause of Death data: reported as follows for 2010-2014: a mean of 2.6 deaths per year; and 1 child death per year, 0 reported farmer deaths.

Table: National estimates for Costa Rica

Population type	Population		Fatal	Non-fatal	Total cases
	Year	**Size**			
General	2010-2014	4,652,770	2.6	NA	2.6
Farming/occupational	2006	259,564	NA	83,060	
Children	2010-2014	1,095,928	1	NA	1

Limitations

The Tomenson and Matthews paper was the only study eligible for data extraction, the sample was a representative one from a survey conducted in 2006.

15. Cote d'Ivoire

Extracted data

Publications extracted for synthesis: 1.

Ajayi et al. (39) was a survey relying on self-reported data on poisonings among cotton farmers from Cote d'Ivoire, with 26 of 132 cotton farmers reporting symptoms.

Estimation of national figures

Ajayi et al. 2011 reported 20% poisoning among cotton farmers: "Pesticide applicators reported health symptoms once for every five times (20%) that they carried out spraying operations. These were the symptoms that began during or within 24 hours after spraying operation." It is possible the data were from prior to 2006, as the date when the survey of the farmers was conducted is unclear. The paper also references a population recruited in a paper from 2007, so it's possible the data were collected pre-2006. In these cases, if the publication date was post-2006, an assumption was made regarding the timing of data collection, i.e., the data were likely collected around or after 2006.

2006 World Bank data on agricultural employment reported 3,185,756 farmers, while the number of cotton farmers in 2006 in Cote d'Ivoire was reported as 72,000 in a 2010 World Bank Report.

0.20 * 72,000 = 14,400 for cotton farmers gives the lower boundary estimate.

WHO Cause of Death data: no mortality data were available.

Table: National estimates for Cote D'Ivoire

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General	NA	NA	NA	NA	NA
Farming/occupational, lower boundary	2006	72,000	NA	14,400	
Children	NA	NA	NA	NA	NA

Limitations

It is possible the data were from prior to 2006, as discussed above. The only estimate we were able to use for Cote d'Ivoire was a survey of cotton farmers which may not reflect all of the agriculture in this country, as major exports include cocoa and coffee.

Sources

Gergely N. The Cotton Growing Sector of Cote d'Ivoire. World Bank; Africa Region Working Paper Series No. 130 (a); June 2010. Available from: http://documents.worldbank.org/curated/en/552341468247813306/The-cotton-sector-of-Cote-dIvoire

From the report (p.17): "The number of cotton growers was estimated at 72,000 for the 2005/06 season (based on seed cotton delivery reports from the ACE), which, for an area devoted to cotton production of 300,000 ha for that season, gives an average cotton production area of 4.2 ha per farm."

16. Ecuador

Extracted data

Publications extracted for synthesis: 1.

Gonzalez-Andrade et al. (40) reported ICD-10 codes from Ecuador's National Register of Hospital Admissions/Discharges and data from the Ministry of Public Health from 2001-2010. Only 2006-2007 data were used for data extraction.

Estimation of national figures

Based on the data reported from 2006-2007 in Gonzalez-Andrade et al. 2010, the estimated fatalities per year for the general population were 74 and the non-fatal cases were 2,168 per year.

WHO Cause of Death data: available for the years 2011-2015.

Table: National estimates for Ecuador

Population type	Population	Fatal	Non-fatal	Total cases

	Year	Size			
General	2006-2007	14,086,467	74	2168	2,242
	2011-2015	15,661,210	14.8	NA	
years combined	2006-2007, 2011-2015	14,873,839	88.8	2,168	2256.8
Farming/occupational	2011-2015	1,848,259	1.4	NA	
Children	2011-2015	4,649,590	2.2	NA	

Limitations

The authors reported that the exposure "seems to be" mostly unintentional—the register did "not contain information about the location of the exposures, but indicates that the poisonings in this study occurred in the workplace". Thus, we assumed that the data reported in the paper have a negligible number of intentional poisonings. An additional assumption was made that the number of fatalities was distributed evenly across the years that data were collected.

17. Egypt

Extracted data

Publications extracted for synthesis: 1.

Lein et al. (41)

- Occupational cohort (workers) exposed to chlorpyrifos and limited pyrethroids
- 31 Egyptian pesticide application workers applying pesticides to cotton, in Menoufia
- self-reported symptoms
- year of data = 2009
- Morbidity = 19/year = 61.3%
- There are 1080 cotton field spray applicators in Menoufia, one of 29 governates of Egypt; sample representative of cotton workers but query whether it can be extrapolated to other farmers and workers; paper states "The Egyptian pesticide workers provide a population with a relatively consistent exposure history stretching back for many years. No information on cotton growing in other governates, although it appears Menoufia is the main area.

Estimation of national figures

WHO Cause of Death data: there were an average of 73.2 fatal poisonings per year reported for the general population of Egypt, including 35.4 children for 2011-2015.

As it has proven impossible to retrieve information on the population of cotton growers or cotton pesticide applicators, a non-fatal occupational rate cannot be established.

Table: National estimates for Egypt

Population type	Year	Population size	Fatal (WHO)	Non-fatal	Total cases
General	2011-2015	89,821,798	73.2		

Farming/occupational					
Children	2011-2015	29,334,902	35.4		

Limitations

- Cotton pesticide applicators only
- Only 1 publication, for one crop
- Small sample size
- Assumption that all farmers and workers are similarly exposed to pesticides as the cotton pesticide applicators, likely to overestimate incidence rate
- However, incident rate only given for highest single symptom, not for any symptom, so actual incident rate likely to be higher than for highest single symptom, so the 2 assumptions may cancel each other out
- Study cannot report incidence of fatalities because it can only elicit symptom incidence from living workers.

18. Ethiopia

Extracted data

Publications extracted for synthesis: 3.

Adinew et al. (42) reported on 543 registered poisoning cases admitted to emergency centres for three hospitals serving the north Gondar area in Ethiopia. Prevalence was calculated as 0.00026 % poisoned during 2010-2014.

Negatu et al. (43) reported on pesticide applicators from small-scale irrigated farms, a large-scale open farm and a large-scale greenhouse (commercial agriculture). 41 reported UAPP symptoms in a representative sample of 256 workers. The years covered were not given but it was assumed that the data were recent enough to be post-2006.

Nigatu et al. (44) reported 2014 data from a representative sample of flower farm workers who reported symptoms, with those reporting two or more typical pesticide intoxication symptoms being assessed as having APP (136 assessed as having APP, n= 516).

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Adinew et al. (2017) 13 non-fatal cases per year with population estimated at 5,000,000. The general population was averaged from 2010-2014 and used to calculate poisoning figures for the entire general population:

0.0000026 * 92,489,621= 240.

Negatu et al. (2018) reported 16.015625% prevalence of APP among pesticide applicators, with the year not specified in the study. An average of the most recent available farmer population data spanning 3 years was taken (2014-2016).

Nigatu et al. (2016) reported APP prevalence of 26% among flower plantation workers in 2014.

Prevalence for the farmer and worker population based on Negatu et al. 2018 and Nigatu et al. 2016 were averaged =

21%: 0.21007813 * 32,052,927 =6733618.89

Table: National estimates for Ethiopia

Population type	**Population**		**Fatal**	**Non-fatal**	**Total cases**
	Year	**Size**			
General	2014-2016	92,489,621	NA	240	
Farming/occupational	2014-2016	32,052,927	NA	6,733,618.89	
Children	NA	NA	NA	NA	NA

Limitations

Negatu et al. (2018) was a representative sample of commercial agriculture pesticide applicators and Nigatu et al. (2016) was a representative sample from flower farm workers. These two studies may not be totally representative of the agriculture in Ethiopia but the APP prevalence from these studies was averaged for the farmers and workers population in Ethiopia.

The general population estimate was based on Adinew et al. (2017) and the prevalence was based on three government hospitals serving an area with an approximate population of 5,000,000 in the north Gondar area. Most of the cases, except for 28 of them, involved patients over 15 years of age, so no data on children were available and no other data were available for the general population.

19. France

Extracted data

Publications extracted for synthesis: 1.
Baldi et al. (45) reported data from the AGRICAN cohort, which surveyed a representative sample of farmers and workers.

Estimation of national figures

Baldi et al. (2014) reported a 7.7 % prevalence for having ever been poisoned for a farmer population, with 81 reporting from a sample of n=1,04: → 0.077 * 751,471 = 57,863.3

WHO Cause of Death data: available (2010-2014)

Table: National estimates for France

Population type	Population		Fatal	Non-fatal	Total cases
	Year	**Size**			
General	2010-2014	65,668,965	3.6	NA	
Farming/occupational	2008	751,471	NA	57,863.3	
Children	2010-2014	12,070,562	0.2	NA	

Limitations

We did not have an eligible study with data on non-fatal poisonings for the general population.

20. Gambia

Extracted data

Publications extracted for synthesis: 1.

Idowu et al. (46) reported data on non-fatal cases (self-reported) for a representative sample of farmers from the Kombo North District of the Gambia.

Estimation of national figures

Idowu et al. (2017) reported a prevalence of 51.52 % prevalence of farmers had symptoms after use (34 cases with sample size n=66). As the data were collected after 2013, an average was taken of the most recent data after 2013 on the farmer population (2014-2016 World Bank data).

0.5152 * 162,169 = 83,541.5

WHO Cause of Death data: no mortality data were available.

Table: National estimates for Gambia

Population type	Population		Fatal	Non-fatal	Total cases
	Year	**Size**			
General					NA
Farming/occupational	After 2013	162,169	NA	83,541.5012	
Children					NA

Limitations

No data on poisonings of the general or child populations were available. No fatal poisonings data for farmers were available.

21. Georgia

Extracted data

Publications extracted for synthesis: 1.

PAN UK (47) collected 2016 data from a representative sample of Kvemo Kartli, Georgia farmers and workers. The survey relied on self-reported data on experiencing signs or symptoms of poisonings over the previous 12 months.

WHO Cause of Death data: available for 2011-2015.

Estimation of national figures

The PAN UK study reported a prevalence of 20% from a sample of 920 farmers and workers in 2016 (184 non-fatal cases per year were calculated).

Table: National estimates for Georgia

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General	2011-2015	3,717,100	0.2	NA	
Farming/occupational	2016	740,545	NA	148109	
	2011-2015	796,746	0	NA	
Children	2011-2015	695,145	0	NA	

Limitations

The single eligible study was a survey of one area of Georgia, which may not be representative of farmers and farm workers in the entire country. In this area, “The main crops include grains (corn, barley and wheat) and vegetable growing (potatoes, tomatoes, onions, beet, cucumber). Fruit orchards are common on smallholdings and a small number of large commercial farmers grow orchard fruits. “

22. Germany

Extracted data

Publications extracted for synthesis: 1.

National mortality data were studied by (48) showing no fatalities for 2005-2010. However, for a more recent period (2011-2015) WHO Cause of Death statistics report 2 cases annually.

Tab: National estimates for Germany

Population type	Population		Fatal	Non-fatal	Total cases
	Year	size			
General	2011-2015	80,803,104	2		
Farming/occupational	2011-2015	597,441	0		
Children	2011-2015	10,718,925	0		

23. Ghana

Extracted data

One study was eligible for data extraction. Ae-Ngibise et al. (49) conducted a cross-sectional survey in December 2011 of randomly selected members (simple sample/not stated) of farmers from Kintampo North and South Municipalities. The data were self-reported, with the most prevalent symptom reported after pesticide application being skin irritation.

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

406 of the 1,040 participants who were pesticide users reported having skin irritation, which was 39.04 %. This figure was used to extrapolate to poisonings for the farmer population of Ghana.

39.04 % *4,592,281 = 1,792,758

Table: National estimates for Ghana

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General					
Farming/occupational	2011	4,592,281	NA	1,792,758	
Children					

Limitations

The sample taken wasn’t described by the authors as representative. Data based on the most prevalent symptom not all symptoms. The study participants were from an area where subsistence farming is common, though it was also noted that some participants used pesticides to control weeds in their as well as use for rodents, head lice and insect control, in addition to their use of DDT for insect control.

24. India

Extracted data

Publications extracted for synthesis: 11.

Banerjee et al. (50)

- 18-month cross-sectional study commencing January 2008 in Burdwan, West Bengal
- Sample = 500 farmers, purchasing pesticides from the Bardhaman Thana Co-operative Agricultural Marketing Society Ltd
- Morbidity = 29.8% for most prevalent symptom
- Data ok to extrapolate

Choudhary (51)

- Period of study = 2009-2011 (28 months)
- 3 villages (Bagarauda, Jhagariya Khurd, Babadiya Khurd) in Misrod, southern suburb of Bhopal, Madhya Pradesh
- Sample = 105 farmers, representative, but all male; crops = principally soybean
- Organophosphates only
- Morbidity = 50% of farmers (males) exposed for 18 months; 20% of farmers exposed for 12 months, and 8.2% exposed for 6 months; for most prevalent symptom; symptoms reported by questionnaire, during or immediately after spraying. The morbidity is averaged over the 3 time periods to be 26.7%
- The study shows that the longer farmers are exposed to pesticides, the more symptoms of APP they display during or immediately after spraying
- "Subjects who self-reported have had two or more of the mentioned symptoms within 24 hours after pesticide spraying were considered to have suffered acute pesticide poisoning." However, the paper does not identify how many there were
- Data ok to extrapolate

Kaur (52)

- Period of study = presumed 2010
- Malwa region of Punjab
- Sample = 88 farm workers, male, purposive sampling, 99% of whom were engaged in spraying pesticides daily during harvesting season (crop not identified)
- Morbidity = 90.91% for highest symptom incidence
- This study is not representative of all farmers and all farm workers but rather reflects those workers who spray frequently
- Does not identify a time period over which the symptoms occurred

Kumar (53)

- Period of study = 2014-15
- Purposive sample of users of paraquat: 23 workers (men and women), including 15 workers from the States of Arunachal Pradesh (small scale tea gardens) and Andhra Pradesh (daily labourers working in small scale tea gardens in Namsai district but also daily labourers

working in cotton, paddy, and vegetable farms; and 8 male workers from Andhra Pradesh, Madhya Pradesh, Telangana, West Bengal
- Paraquat only
- Morbidity = 91.30% for any symptom after spraying
- Cannot be extrapolated beyond paraquat sprayers

Kumari and John (54)
- Period of study = 2016 (assumed)
- Study area = 8 randomly selected villages of Kinnaur district of Himachal Pradesh (Sangla, Rakcham, Kamroo, Sungra, Nichar, Kangos, Lutuksa and Bhabanagar) of Himachal Pradesh
- 96 workers (81 male) on apple orchards
- Representative sample
- Morbidity = 84% for most prevalent symptom, “during and after the spray season”
- Data ok to extrapolate

Patil and Katti (55)
- Period of study = 2010
- Representative sample of 78 workers, closely linked with applying pesticides, in a cash crop zone in Maharashtra, from Shirol region of Kolhapur district
- Morbidity = 97.44% for most prevalent symptom
- Data ok to extrapolate to other sprayers

Rengam et al. (8)
- Period of study = 2017
- 80 farmers and workers in Chittoor, Andhra Pradesh, Mango orchards
- Morbidity = 100% for any symptom ever

Shetty et al. (56)
- Period of study = date not given, may be pre-2006
- Representative sample of 1577 farmers, workers, agricultural officers, pesticide vendors and doctors from 290 randomly selected villages 28 districts in 12 states crops such as paddy, cotton, sugarcane, wheat, apple, pomegranate, mango, grapes and vegetables covering different agroecological zones in India
- Morbidity = 19.4% ever experienced symptoms after handling pesticides – but this may also include vendors and agricultural officers as well as farmers and workers, the paper is unclear on this

Tomenson and Matthews (9)
- Period of study = 2006
- 259 farmers and workers using pesticides
- Morbidity = 39% any symptom of APP over past 12 months

Peshin et al. (57)
- Period of study = 1999-2012
- Annual average morbidity = 130/year

- Based on telephone calls to National Poisons Information Centre, All India Institute of Medical Sciences, New Delhi
- Bears no relationship to results from surveys
- Data is for the general population resulting from phone calls to one centre without information on the catchment area and the coverage, so it is not included.

National Crime Records Bureau (58)

- A report by the National Crimes Records Bureau was available for 2014 and 2015 on accidental deaths from pesticides (NCRB 2016).

Year	**Total deaths**
2014	5915
2015	7060
average	*6488*

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

We averaged the percentages of acute pesticide poisonings across studies referring to farmers/workers and excluded those that report on specific pesticides only (paraquat, OPs) or populations (sprayer). We based the extrapolation on an average farmers/workers population for the respective years.

For the general population, results from Peshin et al. 2014 were used. However, no information on the catchment area and the coverage was given so this might not be related to the total population.

Study	**Year**	**Sample size**	**Popul-ation**	**Pesti-cide**	**Morbi-dity**	**Sym-ptom range**	**Timeframe**	**Extra pola-ted**	**Study strength**
Banerjee 2014	2008-10	500	F	all	29.8%	highest	Unclear – 18 months?	+	+
Choudhary 2014	2008	105	F	OPs	26.7%	highest	6,12,18 months	X	
Kaur 2016	2010?	88	sprayers	all	90.91%	highest	?	X	
Kumar 2015	2014-15	23	W	paraquat	91.3%	any	?	X	
Kumari & John 2018	2016	91	W	all	84%	highest	?	+	++
Patil 2012	2010	78	W	all	97.44%	highest	?	+	+
Rengam 2018	2017	80	F&W	all	100%	any	?	+	
Shetty 2011	?	1577	F,W, ag officers vendors, doctors	all	19.4%	any	ever	+	
Tomenson 2009	2006	259	F&W	all	39%	any	12 months	+	+

Study	Year	Sample size	Popul-ation	Pesti-cide	Morbi-dity	Sym-ptom range	Timeframe	Extra pola-ted	Study strength
Peshin 2014	1999-2012	national	Phone calls		130/yr	any	12 months	X	
	Average				*62 %*				

Table: National estimates for India

Population type	Year (average)	Population size	Fatal	Non-fatal	Total cases
General	2006-2012	1,204,809,655	6,488	130	
Farming/occupational	2006, 2008-2010 2016	233,879,104		145,005,045	

Limitations

The Government report on mortality did not report any data on farmer/occupational or child deaths.

25. Indonesia

Extracted data

Publications extracted for synthesis: 4.

Perwitasari et al. (59)

- Period of study = 2006
- Organophosphates only
- Kulon Progo County
- 84 farmers using OPs during onion planting season, recruited from 3 onion farmer groups
- Morbidity = 39.29% for any symptom
- Data should not be extrapolated beyond onion farmers

Rengam et al. (8)

- Period of study = 2016-17
- Sample = 57 oil palm plantation workers selected from 4 plantations (different companies)
- Morbidity = 82.46% – for most prevalent symptom (NB changed from extraction).
- There are 10,400,000 plantation workers in Indonesia (Zidane 2018)
- Data ok to extrapolate only to oil palm plantation workers

Sekiyama et al. (60)

- Period of study = 2006
- Sample = 73 farmers from two villages in the watershed of the Citarum River, Bandung district, West Java (crops, tea planting, dairy farming)

- Morbidity = 63% for most prevalent symptom; farmers experienced an average of 6.7 symptoms each; ever experienced after spraying
- Data ok to extrapolate to other farmers

Tomenson and Matthews (9)

- Period of study = 2006
- 290 farmers and workers using pesticides, representative sample, ok to extrapolate
- Morbidity = 28.28% any symptom of APP over past 12 months

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Study	Year	Sample	Population	Pesticides	Morbidity	Symptom range	Timeframe	Extrapolate
Perwitasari et al. 2017	2006	84	onion farmers	OPs	32.29%	any	?	x
Rengam et al. 2018	2016-17	57	oil palm plantation workers	all	82.46%	highest	?	+
Sekiyama et al. 2007	2006	73	farmers	all	63%	highest	ever	+
Tomenson & Matthews 2009	2006	290	farmers and workers	all	28.28%	any	12 months	+
	average	*2006*	*farmers & workers*		*43.14%*			+

Table: National estimates for Indonesia

Population type	Year (average)	Population size	Fatal	Non-fatal	Total cases
Oil palm plantation workers	2018	10,400,000	NA	8,575,840	
Other farmers/workers	2016	27,853,604	NA	12,016,044	
Total farmers/workers	2016	38,253,604	NA	20,591,884	

The population of non-plantation farmers/workers is derived from the total farming population less the estimated number of oil palm plantation workers and these two populations are treated separately and then combined to provide an overall estimate of non-fatal APP for farmers and workers.

Limitations

Three of the four studies were at the lower cut-off level for dates (2006) and the only recent study was of small sample size, meaning that the extrapolations and resulting estimates are tenuous. One of the 4 studies applied only to onion farmers and, as no estimates for the number of onion farmers in Indonesia could be found and there were other studies covering a wider range of crops, this study was not used. There was a discontinuity of dates for studies and population estimates. There was no data on mortality.

Source:

Zidane. Indonesia: Exploitation of Women and Violation of Their Rights in Oil Palm Plantations. Bulletin 236; World Rainforest Movement; 2018 March 7. Available from https://wrm.org.uy/articles-from-the-wrm-bulletin/section1/indonesia-exploitation-of- women-and-violation-of-their-rights-in-oil-palm-plantations/

26. Iran

Extracted data

Publications extracted for synthesis: 5.

Afshari et al. (61)

- Period of study = 2017
- Twiserkan County, Hamadan province, west Iran, an important province in agricultural production (wheat, barley, garlic, almonds, peach, plum, apple, and especially walnuts)
- Sample = 474 farmers and workers who had used pesticides at least 1 week before interview; 73% of farmers themselves sprayed pesticides
- Morbidity = 60.34% for at least one symptom within 48 hrs of spraying, during the past 7 days
- Data ok to extrapolate

Ahmadi et al. (62)

- Period of study = 2006-8
- descriptive and retrospective study was conducted at the poisoning ward of Imam teaching hospital, Sari city, Northern Iran - Mazandaran province
- General population; 9 cases in an estimated population of over 500,000 = 0.0018%
- Hospitalised cases only
- Data ok to extrapolate

Hashemi et al. (63)

- Period of study = date not stated
- Representative sample = 132 farmers “who usually engage in” pesticide use and handling from Ashjerd village of the County Marvdasht in Fars Province in the southwestern part of Iran
- Morbidity = 37% for any symptom, ever experienced after spraying
- Data ok to extrapolate to other farmers

Sharafi et al. (64)

- Period of study = date not stated
- Kermanshah province,

- 311 farmers, all male, older than 21 years old, their main income was depended on agriculture, and were working on minimum 5 and maximum 10 ha of agricultural lands within Kermanshah province during the past year
- Growing wheat and barley (68.1%), chickpea (21.3%), and industrial crops (8.0%). Industrial crops include corn, sugar beet, and rapeseed
- Morbidity = 80.7% for most prevalent symptom
- Representative sample, ok to extrapolate

Soltaninejad et al. (65)

- Period of study = 2007-2010
- Aluminium phosphide only
- Patients with acute “rice tablet” poisoning who were admitted to Loghman Hakim Hospital Poison Center, Tehran
- Mortality = 0.000007% (n = 1)
- Morbidity= 0.000021% (n = 3)
- Data not ok to extrapolate as single pesticide only

Synthesis

Study	**Year**	**Sample**	**Population**	**Pesticide**	**Morbid-ity**	**Mortality**	**Symptom range**	**Time**	**Extrapo-lated**
Afshari 2018	2017	474	farmers & workers	all	60.34 %		any	Previous 7 days	+
Ahmadi 2010	2006-8	57	general	all	0.0018%		hospitalized	?	x
Hashemi 2012	?	132	farmers	all	37%		any	ever	+
Sharafi 2018	?	311	farmers	all	80.7%		highest	?	+
Soltaninejad 2017	2007-10		general	aluminum phosphide	0.000021%	0.000007 %	hospitalized		X
	average	*2006-*	*farmers & workers*		*59.35 %*				*+*

Estimation of national figures

The three studies on farmers and workers were averaged without weighting to arrive at an occupational morbidity of 59.35%.

The study by Ahmadi et al 2010 does not give information on the catchment area and coverage of the hospital, so the study results were not considered for national estimates.

WHO Cause of Death data were available for 2013-2015. From the general population 154 deaths were reported, including 61 children.

Table: National estimates for Iran

Population type	Year (av)	Population size	Fatal	Non-fatal	Total cases
general	2013-2015	79,360,487	51.3		
farming/occupational	2015	4,159,700		2,468,782	2,468,782
children	2013-2015	18,451,873	20.3		

Limitations

There was a discontinuity of dates for studies and population estimates.

27. Italy

Extracted data

Publications extracted for synthesis: 1.

Settimi et al. (66) reported accidental poisoning cases from poison control centres in Milan, Pavia, and Bergamo in 2006 from February 1 to March 31 in Piedmont region.

Estimation of national figures

The Piedmont region was reported in a 2009 OECD book (OECD 2009) as 4.34 million in 2006, and the prevalence of poisoning extrapolated to the year 2006 from the Piedmont region was 0.00082949%. The general population for Italy in 2006 was 58,143,979.

0.00082949% * 58,143,979 = 482.298491

The WHO Cause of Death database had data for Italy from 2011-2015.

Table: National estimates for Italy

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General [HA]	2006	58,143,979	NA	482.298491	
	2011-2015	60,134,567	2.2	NA	2.2
years combined	2006,2011-2015	59,139,273	2.2	482	484.2
Farming/occupational	2011-2015	817,478	0.2	NA	0.2
Children	2011-2015	8,338,728	0.2	NA	0.2

Limitations

The single paper we used for extrapolating nationally for accidental poisonings was based on the Piedmont region of Italy only, which may not be representative of the entire country for accidental poisonings.

Sources

OECD Reviews of Regional Innovation: Piedmont, Italy 2009, p. 72 Table 2.1 Population and change 1990-2006, by Italian region; OECD publishing; 2009. Available from: https://books.google.com/books?id=hFdvgXvIv6wC&dq=population+of+piedmont+italy+2006&source=gbs_navlinks_s

28. Jamaica

Extracted data

Publications extracted for synthesis: 1.

Ncube et al. (67) reported data from 349 farmers surveyed for self-reported symptoms in 2006. 16 % reported "one or more incidents of acute pesticide poisoning within the last two years".

National mortality data were from the WHO Cause of Death database, which reported two cases in the period 2009-2011, averaged to 0.7 cases per year. No fatalities were reported for children or farmers.

Estimation of national figures

Population data were not available from World Bank. The general population for 2011 was taken as 2,825,929 from worldometers (https://www.worldometers.info/world-population, http://worldpopulationreview.com/countries/jamaica-population/). The percentage of the rural population was given as 45%, and 30% of the population were younger than 14 years. So we assumed a farmer population of 1,271,668 and a children population of 847,778.

Estimation of UAPP for farmers was based on the above mentioned prevalence of 16%.

Table: National estimates for Jamaica

Population type	**Population**		**Fatal**	**Non-fatal**	**Total cases**
	Year	**size**			
General	2009-2011	2,825,929	0.7		
Farming/occupational	2011	1,271,668	0	203,466	203,466
Children	2009-2011	847,778	0		

Limitations

The farming population might not provide a good basis for extrapolation, as not all of the rural population will be exposed to pesticides. On the other hand, UAPP does also occur in urban populations. The prevalence of UAPP from Ncube et al. might be not a yearly prevalence.

29. Kenya

Extracted data

Publications extracted for synthesis: 3.

Macharia et al. (68) reported data from a representative sample of farmers from seven major vegetable producing districts of Central Province (Kiambu, Kirinyaga, Murang'a, Nyandarua, and Nyeri North) and Eastern Province (Makueni and Meru Central), surveyed in 2005 and 2008. The data were self-reported, with 363 farmers surveyed in 2008.

Mureithi et al. (69) collected 2006-2007 data from a representative sample of 140 small farmers raising horticultural crops for commercial purposes in Sagana, Central Highlands, Kenya and found breathing problems to be the symptom of highest prevalence.

Ngolo et al. (70) surveyed small-scale farmers in Ewaso Narok wetland, Laikipia County, Kenya in May-August of 2016. The sample of 86 farmers was reported as a simple sample/not stated. The highest symptom prevalence reported was headache, and 40 farmers reported experiencing this after pesticide application.

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Macharia et al. (2015) reported a prevalence of non-fatal pesticide poisonings symptoms of 34% for vegetable farmers. Mureithi et al 2011 reported a prevalence of non-fatal pesticide poisonings symptoms of 25% for farmers. Ngolo et al 2018 reported 46.51% prevalence of non-fatal pesticide poisoning symptoms for the farmers surveyed.

The prevalence was averaged for farmers =35.17%.

National estimate: 0.3517*5,399,851= 1899127.75

Table: National estimates for Kenya

Population type	**Population**		**Fatal**	**Non-fatal**	**Total cases**
	Year	**Size**			
General	NA				
Farming/occupational	2006-2007,2008,2016	5,399,851	NA	1899127.75	
Children	NA				

Limitations

We don't have specific information on the populations of different types of farmers in Kenya. The three studies surveyed farmer populations who were growing vegetables. Only one study (Macharia et al) described the sample population as "representative." In Macharia et al., one of the districts had farmers who were more likely to use PPE, which resulted in significantly less pesticide poisonings.

Based on the three studies, it isn't clear if many other areas in Kenya might also have farmers more likely to use PPE.

30. Kuwait

Extracted data

Publications extracted for synthesis = 1

Jallow et al. (71)

- Years covered – not given, but post-2010
- Occupational – reported as farmers only, but likely to be workers also as the majority of farms are operated by expatriate labours from India and North Africa
- Sample size = 250, representative, from the 2 major agricultural regions (Wafra and Abdally) which accounts for 90% of total crop production (dates, vegetables, cereals, pulses, and forages), so extrapolation is appropriate
- Self-reported symptoms = 205
- Morbidity = 205/year = 82% having at least one symptom

WHO Cause of Death data:

- 2.4 cases annually in whole population (2010-2014)
- child fatality = 0.2/yr (2010-2014)
-

Estimation of national figures

Table: National estimates for Kuwait

Population type	**Year**	**Size**	**Fatal**	**Non-fatal**	**Total**
General	2010-2014	3,393,105	2.4	?	?
Farming/occupational	2014	67,233	0	55,131	
Children	2010-2014	753,842	0.2	?	

Limitations

There was only one publication and the actual year of the data is unknown, but post-2010.

31. Lao DPR

Extracted data

Publications extracted for synthesis: 1.

Schreinemachers et al. (22)

- Period of study =2015.
- Occupational – farmers only, and only yard-long bean and leaf mustard growers
- Sample size = 300, representative, self-reported symptoms
- Morbidity = 117/year = 39% incident rate for highest symptom incidence only

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Table: National estimates for Laos

Population type	Year	Population size	Fatal	Non-fatal	Total cases
General	2015	6,663,967	?	?	
Farming/occupational	2015	2,165,187	?	844,423	?
Children		?	?	?	?

Limitations

There was only one study and that of farmers only growing two specific crops. An assumption was made that the outcomes are similar for other farmers. The prevalence in the study is only given for the highest single symptom reported, so the actual incident rate is likely to be higher. As with all the farmer/worker surveys this study cannot report incidence of fatalities because it can only elicit symptoms reported by living farmers.

32. Malawi

Extracted data

Publications extracted for synthesis: 1.

Donga and Eklo (72) surveyed between June 2015 and January 2016; a representative sample of 55 sugarcane farmers responding to a questionnaire which included a question asking what acute symptoms of pesticide exposure had been experienced ever.

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

The most prevalent symptom reported was skin irritation with 78% of farmers (43 of 55) reporting having experienced this symptom →

0.78 * 6,075,069 farmers in Malawi = 4738553.9

Table: National estimates for Malawi

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General	NA				
Farming/occupational	2015-2016	6,075,069	NA	4,738,553.9	
Children	NA				

Limitations

This is the only study available for Malawi, and so the national estimate was based on self-reported poisonings by sugar cane farmers. The study authors report that sugarcane is the 2nd most valuable crop after tobacco, but a 2015 FAO report does not contain the number of sugarcane farmers — possibly due to the focus or because the farming situation is complex, as large estates make up the majority (84%) of those growing sugarcane, with the rest of the crop grown by smallholder farmers.

Source

FAO. Review of Food and Agricultural Policies in Malawi: Country report 2014. Rome: Food and Agriculture Organization of the United Nations; 2015. Available from: http://www.fao.org/3/a-i4675e.pdf

33. Malaysia

Extracted data

Publications extracted for synthesis: 3.

All studies were from the National Poisons Control Centre, giving national figures. However, one paper studied the herbicide paraquat only, and one paper focused on children only.

Nur et al. (73)

- Cases reported to the National Poisons Centre of Malaysia, 2006-2009
- Children only
- Morbidity = 440 cases = 110/yr x 85%; accidental = 93.5/yr
- Likely to be an underestimation as 60.1% of cases were toddlers and no suicides reported in this group

Leong et al. (74)

- Period of study = 2004-2015
- Paraquat only
- Paraquat poisoning calls to the Malaysia National Poison Centre following its ban and subsequent restriction
- Morbidity = 35 cases/yr, but may include mortality

Tangiisuran et al. (75)

- Evaluation of poisoning exposure calls managed by the Malaysia National Poison Centre (2006–2015)

- Morbidity for UAPP = 420 /yr

WHO Cause of Death data: Average 2010-2014 = 13.2yr, including 0.2 child.

Estimation of national figures

All 3 papers covered different populations, but the Leong et al paper on paraquat is excluded from the synthesis as it covers only one pesticide and is rendered unnecessary by the other papers.

Table: National estimates for Malaysia

Population type	years	Population size	Fatal	Non-fatal	Total cases
General	2010-2014	29,170,523	13.2		
	2006-2015	28,148,720		420	
	years combined	28,406,163	13.2	420	433.2
Farmers/occupational					
Children	2010-2014	7,766,219	0.2		
	2006-2009	7,807,418		93.5	
	years combined	7,897,418	0.2	93.5	93.7

Limitations

- No information on occupational poisoning.
- Only two studies were deemed relevant, as the third was for only one pesticide.
- Slight disconnect with the dates of the various bits of data, but seriously so.
- Only cases reported to National poisons centre.

34. Mexico

Extracted data

Publications extracted for synthesis: 1.

Gonzales-Santiago et al. (76) dealing with unintentional and self-poisoning mortalities from 2000-2012 was available. The supplementary tables contain national data on a yearly basis using ICD-10 codes. Table S2 provides data for unintentional poisoning and Table S3 the population data. From this it was possible to derive data for unintentional pesticide poisoning for 2006 to 2011 and calculate the annual average for the general population and for children. The paper contains fatal poisoning data, but not population data for this year. These fatalities data were older than those provided by WHO and, therefore, not used.

WHO Cause of Death data: available from 2011-2015.

Estimation of national figures

Table: National estimates for Mexico

Population type	Population		Fatal	Non-fatal	Total cases
	Year	**Average size**			
General	2011-2015	122,513,368	114.6		
Children	2011-2015	34,760,975	18.2		
Farmers	2011-2015	6,946,281	8.0		

35. Moldova

Extracted data

Publications extracted for synthesis: 1.

Pinzaru et al. (77) reviewed records from local registers and a reporting mechanism for states in Moldova from 2011-2015 for the general population, for chemical poisonings. For pesticides, around 90% of the 52 reported fatal cases were suicides.

The most recent data from the WHO Cause of Death database were from the 2012-2016 period.

Estimation of national figures

Cases were reported for fatalities and non-fatal poisonings per year, given as 1 fatality per year and 28.28 non-fatal poisoning cases per year.

Table: National estimates for Moldova

Population type	Population		Fatal	Non-fatal	Total cases
	Year	**Size**			
General	2011-2015	3,557,715		28.28	
	2012-2016	3,551,954	4		
Farming/occupational	2012-2016	370,828	0		
Children (1-18 years)	2011-2015	566,948	0.4	56.4	56.8

Limitations

For fatal poisonings, Pinzaru et al. stated that 90% were suicides. However, it was not clear if there were any intentional cases among the non-fatal poisonings recorded, though it is highly likely that there would be less intentional poisonings among the non-fatal cases. In calculating the non-fatal cases of pesticide poisoning per year, the assumption was made that all of the cases were accidental. In discussing the non-fatal cases, Pinzaru et al. 2017 stated: “Lately, frequent cases of accidental poisonings with pesticides were registered in Republic of Moldova, particularly within the pre-university education institutions”. And: “In the past years, it was registered an increasing number of cases of lethal chemical poisoning both for adults and children, which occurred accidentally, or as suicides (defined as intentional self-poisoning).”

36. Morocco

Extracted data

Publications extracted for synthesis: 2.

Imane et al. (78)

- Period of study = 2008
- Occupational – farmers only, mostly engaged in cereals, fodder, potatoes, onions, vineyards, orchards
- Cross-sectional study; sample size = 402 farming households in 15 rural communes in the district of Meknes El Hajeb in the north-east
- Self-reported symptoms
- Morbidity = 83/year = 20.6%
- 80.5% don't wear protective mask, only 6.3% wore impervious gloves every time.
- 35.3% are illiterate
- Extrapolation is appropriate

Tomenson and Matthews (9)

- Period of study = 2006
- Survey conducted by market research company for Syngenta, across many countries targeting smallholder knapsack sprayers, in regions of moderate to very intensive use of pesticides, users said to be at highest risk of exposure
- 250 participants; 62% were farm owners, <1% contractors so the rest are presumably workers
- Morbidity = 213 in past 12 months = 85.2% - including 8 'serious' cases (hospitalisation), 47 'moderate' (requiting trained medical assistance) cases and the rest regarded as 'minor'

WHO Cause of Death data: available for the time period from 2010-2014.

Estimation of national figures

Both studies are of a similar time period, slightly preceding the WHO mortality data. One claims to be of users at highest risk and can be assumed to be an upper limit; the other doesn't make any claim about exposure, so the prevalence was averaged without weighting.

20.6% + 85.2% / 2 = 52.9%.

This figure was then applied to the farming population averaged over 2009-2014.

Table: National estimates for Morocco

Population type	Year	Population size	Fatal	Non-fatal	Total cases
General	2009-2014	33,122,500	14.6	?	?
Farming/occupational	2009-2014	4,189,286	0	2,216,132	0
Children	2009-2014	9,338,992	0.8	?	?

Limitations

- Demographic and WHO mortality information were not from same years as the studies.

37. Nepal

Extracted data

Publications extracted for synthesis: 4.

Three studies reported results from cross-sectional surveys on a district level (79), (80), (81), one studies regional hospital admissions (82). So, all studies require additional data for the estimation of national figures.

The study of Gyenwali et al. was carried out 2015 in Chitwan which according to the authors is one of 75 districts in Nepal and is inhabited by 2.2% of Nepal's population. It is located in the south-central part of the country and known for its commercial vegetable farming where pesticides are used extensively. Study basis is four major hospitals which were purposively selected as people from Chitwan mostly visit them for all medical emergencies. The authors state the population at risk and calculate the annual incidence rates of unintentional pesticide poisoning in Chitwan district of 6.99 per 100,000 population derived from 44 hospital admissions in 2015. The cases likely include fatalities which were not differentiated for non-intentional poisoning. The overall fatality ratio was stated as 3.8 %.

The study by Neupane et al. took also place in the district of Chitwan and was carried out in 2012. The study is based on a representative sample of 90 commercial vegetable farmers. The authors reported the prevalence of symptoms based on a list derived from of the WHO classification tools on clinical symptoms of acute organophosphate and carbamates poisoning. Additionally to asking "Did you suffer from any of the following symptoms in the last month?" they recorded whether these symptoms were recognized "immediately after spraying pesticide". However, for the latter the authors gave only the lifetime prevalence. We extracted the prevalence for "blurred vision" which was most often among those experiencing symptoms within the last month (56 %) as well as "ever" (78 %).

The study by Bhandari et al. was carried out at Gaidahawa Rural Municipality in the Rupandehi district of Nepal with no given year but assumedly after 2008. The population of the municipality was stated as 47,565 individuals. The Gaidahawa Rural Municipality is comprised of nine wards – the smallest administrative unit. The study selected wards where the majority of the farmers are engaged in commercial vegetable farming. Each ward is comprised of a number of villages. A random 10 % sample of the households (n=183) were selected for the study. "Almost all" farmers perceived acute health symptoms after pesticide application. The most frequently self-reported toxicity symptoms were headache (73.8%). Neither specific information was given on the questionnaire's wording nor of the study year.

The cross-sectional study of Singh et al. included 262 tea workers of Haldibari, Danabari and Kanyam tea estates of Nepal and reported a prevalence of 34 % for eye irritation as the most often stated symptom. The paper is a short communication only. No details on the sample, the questionnaire and the study year were given; no assessment of the study quality could be made. Tea cultivation seems not to have a larger share in Nepal's agriculture. Given these restrictions we do not use this paper for estimation.

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Based on the above-mentioned studies the situation of pesticide poisoning in vegetable farming seems to be reasonably well addressed. According to FAO in Nepal 66 % of the population is directly engaged in farming which is mostly subsistence (http://www.fao.org/nepal/fao-in-nepal/nepal-at-a-glance/en/). Population data are taken from World Bank data for the year 2015 (general) and for 2012 (farming) calculated from all population: (27,649,925) x 66% = 18,248,951.

We averaged the prevalence of poisoning from the studies by Neupane et al. (56%) and Bhandari et al. (74 %) but refrained from weighting as the studies differ with respect to the sample as well as the definition of poisoning. The average prevalence of 65 % is used to estimate annual national figures:

All cases of UAPP based on farming population: 0.65 x 18,248,951 = 11,861,817 cases

For hospital admissions we assume that the situation in Chitwan can be transferred to the whole country giving 6.99 x 286/100.000 = 2003 nation-wide cases.

Limitations

Commercial vegetable farming was addressed in studies but might differ from subsistence farming with respect to pesticide use.

Table: National estimates for Nepal

Population type	**Population**		**Fatal**	**Non-fatal**	**Total cases**
	Year	**size**			
General	2015	28,656,282			2,003
Farming/occupational	2012	18,248,951		11,861,817	
Children					

38. Nigeria

Extracted data

Publications extracted for synthesis: 3.

Bassi et al. (83) collected self-reported data from a representative sample of 250 farmers from the Fadan Daji district of the Kaduna state, described as a major farming area. The data were assumed to have been collected in 2006 or later based on the publication date and the 2006 census data used in the study.

Oluwole and Cheke (84) reported data from a representative sample of 150 farmers from Ekiti state, Nigeria, who reported symptoms within 48 hours of pesticide sprays. The major crop in the area is rice followed by cash crops (cocoa, kola nut), horticultural crops (vegetables, fruits) and cowpea. The most prevalent symptom reported by farmers was eye irritation, with 91.3% prevalence. Interviews were conducted March 2008.

Ugwu et al. (85) surveyed a representative sample of 150 vegetable farmers from Oyo State, Nigeria. 74% of the farmers had at least one health symptom from pesticide handling. The data were collected in 2014, Table 4 (health effects pesticide use) notes "Field survey, 2014" at bottom.

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Bassi et al. 2016 participants reported cough as the most prevalent symptom, with 106 of 250 (42%). The farming population was averaged for the most recent 5 years (2012-2016).

Oluwole and Cheke 2009 reported 91.3% prevalence of eye irritation for farmers, data were from 2008.

Ugwu et al. 2015 reported 74% experiencing at least one symptom when handling pesticides for the farmer participants, data were from 2014.

The prevalence was averaged for the three studies = 69.1%

= 0.691*19,196,739 =13,264,946.7

Table: National estimates for Nigeria

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General	NA				
Farming/occupational	2008, 2012-2016, 2014	19,196,739		13264946.7	
Children					

Limitations

Bassi et al. reported cough as the most prevalent symptom after pesticide use, but the timeframe of exposure was not reported in the study (i.e., ever experienced or in the past year were symptoms noted). The year the data were collected was also not expressed. It was assumed that this was an annual prevalence for estimates. The same was done for the other studies, as farmers were reporting symptoms but not expressing the timing of the symptoms. A diversity of farmers was surveyed in the different studies but figures for the rice farmer population in Nigeria was not found for the studies. For instance, the dominant crop was rice in the area surveyed by Oluwole-Cheke 2009. This however does not mean that the farmers surveyed grew only rice.

39. Pakistan

Extracted data

Publications extracted for synthesis: 3.

Bakhsh et al. (86)

- Period of study = 2010
- 270 Women cotton pickers in Vehari district, southern Punjab; representative sample from 10 villages; Vehari = 9% of cotton Production in Punjab, so extrapolation to all cotton pickers is sound
- Cotton picking is solely done by women in Pakistan – about 0.1 million women, highly exposed to residual pesticides
- Compares BT cotton to non-BT cotton: morbidity = 61 % BT cotton pickers reported one or more health effects of pesticide during picking season, whereas this percentage for non-Bt cotton households was 66 %; for 2 or more symptoms 35%/38% (BT/non-BT); highest symptom occurrence in BT = 23% (headache), non-BT = 58% (headache)
- The Bt cotton and non-BT cotton morbidity were averaged, = 61.8%

Kouser and Qaim (87)

- Period of study = Dec 2010 to Feb 2011, immediately following cotton harvest
- 325 cotton farmers, representative sample from four major cotton producing districts (Vehari, Bahawalnagar, Bahawalpur, Rahimyar Khan) in Punjab, which has 80% of the cotton crop so extrapolation is sound. 248 were Bt (or partial Bt) growers and 104 non-Bt growers
- Bt varieties reached 5.9 million acres in 2010, which is 75% of Pakistan's total cotton acreage
- Morbidity = 40.34%

Tahir and Anwar (88)

- Period of study = date not given, but $\leq$ 2012
- 30 women cotton pickers in Multan and Bahawalpur Divisions, the major cotton growing areas of Pakistan
- Morbidity = 100% suffering headache, vomiting and nausea
- Weak study, small sample size, selection of participants not explained

WHO Cause of Death data: no mortality data were available.

Estimate of national figures

1) Women cotton pickers: (63.5% +100%) /2 = 81.75% X 100,000 = 81,750
2) Cotton farmers = 40.34%
3) Average the morbidity over all = 61.01%

We have not been able to find the number of cotton farmers; nor is there data to determine whether or not APP in cotton production and harvesting reflects APP throughout the farming sector. Therefore, these data are not extrapolated beyond cotton pickers.

Table: National estimates for Pakistan

Population type	Year	Population size	Fatal	Non-fatal (estimated)	Total cases	Incidence (non-fatal)
General	2010	170,560,182				
Farming/occupational	2010	100,000 female pickers only		81,750		81.75%

Limitations

The studies are weak and apply only to cotton farming; the population of cotton farmers in the country could not be found and extrapolation to other farming is questionable.

40. Palestine

Extracted data

Publications extracted for synthesis: 3.

El-Nahhal (89)

- Period of study = 2015-16
- 4 locations in Gaza Strip
- Sample = 169 farmers and workers from 67 greenhouses
- Morbidity = 47.3% for most prevalent symptom
- Data ok to extrapolate

Yasser (90)

- Date of survey unknown
- Gaza Strip
- Sample = 139 farmers and workers from 57 greenhouses
- Morbidity = 18.7% for most prevalent symptom
- Data ok to extrapolate

Zyoud et al. (91)

- Period of study = 2008
- Nablus district, West Bank; the villages of Tammun, Tubas, EL-Far'a, Tayasir, and Nassariyah, 20 km north-east of Nablus city. These five regions are characterized by important agricultural activity (potatoes, onions, carrots, tomatoes, cucumbers, bitter gourds, cabbage, and cauliflowers)
- Representative sample = 381 farm workers who work in open fields or greenhouses or both
- Morbidity = 37.5% for most prevalent symptom
- Data ok to extrapolate

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

The 3 studies on farmers and workers were averaged without weighting to arrive at a percentage occupational morbidity of 34.5%.

Study	Year	Sample	Population	Morbidity	Symptom range	Time frame	Extrapolation
El-Nahhal 2017	2015-6	169	farmers & workers	47.3%	highest	?	+
Yasser 2016	?	139	farmers & workers	18.7%	highest	?	+
Zyoud 2010	2008	381	workers	37.5%	highest	?	+
	average		*farmers & workers*	*34.5%*			

Table: National estimates for Palestine

Population type	Year	Population size	Fatal	Non-fatal	Total
General	2010, 2016	4,181,334	?		
Farming/occupational	2010, 2016	81,489	?	28,113	

Limitations

No mortality data were available.

41. Philippines

Extracted data

Publications extracted for synthesis: 4.

Del Prado-Lu (92)

- Years covered not stated
- 26 farms selected from 6 villages (barangays) in Sta. Maria, Pangasinan
- Representative sample = 58 farmers and workers growing eggplants
- Morbidity = 100%
- Medical attention not sought
- Data ok to extrapolate

Lu (93)

- Years covered not stated – 2007?
- Benguet, the largest vegetable producing region in the northern part of Luzon, major crops = tubers, roots, bulbs, leafy vegetables, stems and flowers
- Sample = 400 vegetable farmers
- Morbidity = 48%
- Data ok to extrapolate

Lu and Cosca (94)

- Years covered not stated – 2007?
- Benguet
- Representative sample = 542 vegetable farmers from 6 communities
- Morbidity = 51%
- Data ok to extrapolate

Perez et al. (95)

- Period of study = 2014, Aug-Sept
- Southern Mindanao: the Municipality of Baungon and City of Valencia in Bukidnon Province; Municipalities of Alubijid and El Salvador in Misamis Oriental; Municipality of Panaon and City of Oroquieta in Misamis Occidental; Municipalities of Tukuran and Molave in Zamboanga del Sur
- Sample = 528 farmers, growing rice, corn, cassava
- Morbidity = 32.95% (most prevalent symptom)
- Data ok to extrapolate

WHO Cause of Death data: For 2007-2011: 134 fatalities, including 22 children and 1 farmer, = 26.8/yr (general) 4.4 (child) and 0.2 (farmer).

Estimation of national figures

Study	Year	Sample	Population	Morbidity	Symptom range	Time covered	Extrapolated
Del-Prado Lu 2015		58	farmers & workers	100%	all	?	+
Lu 2011		400	farmers	48%	all	?	+
Lu & Cosca 2011	2008	542	farmers	51%	all	?	+
Perez et al. 2015	2014	528	farmers	32.95%	highest	?	+
	average		*farmers & workers*	*57.99%*			

The 4 studies on farmers and workers were averaged without weighting to arrive at a percentage occupational morbidity of 57.99%.

Because three of the four studies do not have dates but are likely to be towards the earlier time threshold of 2006, and data on mortality is only available for 2007-2011, that time frame is used for the estimates.

Table: Population estimates for Philippines

Population type	Year (average)	Population size	Fatal	Non-fatal (estimated)	Total cases	Incidence (non-fatal)
General	2007-2011	92,254,159	26.8			
Farming/occupational	2007-2011	12,379,212	0.2	7,178,705		57.99%
Children	2007-2011	31,967,575	4.4			

Limitations

One of the studies has morbidity only for the highest prevalence symptom, the rest of the studies report for any symptom experienced. Three of the four studies do not identify the year of the survey, and three of the four studies involve the same author.

42. Portugal

Extracted data

Publications extracted for synthesis: 1.

Tomenson and Matthews (9) is a survey of pesticide applicators and farmers commissioned by Syngenta Crop Protection among 2,431 users in eight countries. Tomenson and Matthews 2009 reported survey data of a representative sample of farmers and pesticide users from Portugal and pesticide poisoning incidents, serious, moderate and minor. The total number of farmers experiencing these in the past 12 months was 85 of 250, or 34%.

Estimation of national figures

The farmer population was averaged from 2006 and 2010-2014.

0.34 *541,041 = 183953.853

WHO cause-of-death data were available for 2010-2014.

WHO Cause of Death data: no mortality data were available.

Table: National estimates for Portugal

Population type	Population		Fatal	Non-fatal	Total cases
	Year	**Size**			
General	2010-2014	10,500,772	3.2		
Farming/occupational	2006, 2010-2014	541,041	0	183,953.853	
Children, ages 0-14	2010-2014	1,534,417	0.2		

Limitations

The only data on pesticide applicator/farmer poisonings available were from Tomenson and Matthews, which was collected from 2006. No data were available on non-fatal pesticide poisonings for the general or child population.

43. Saudi Arabia

Extracted data

Publications extracted for synthesis: 2.

Alzahrani et al. (96)

- Period of study = 2011-2015
- Accidental, 28 non-fatal cases/yr in Jeddah only
- Fatalities could not be extracted as the figures included intentional poisonings as well as accidental
- Based on a review of records of cases reported to the Jeddah Health Affairs Directorate

Alnasser et al. (97)

- Only aluminium phosphide poisoning
- Period of study = 2006-2017
- National figures, poisonings reported to Ministry of Health
- Accidental and occupational
- Mortality = 1/ year
- Morbidity = 4.4/yr
- Not ok for extrapolation

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

No occupational figures are provided, and no occupational incident rate can be estimated.

Table: Population estimates for Saudi Arabia

Year	Population Saudi Arabia (WB)	Population of Jeddah (WPR)	Jeddah population as % of total	Average cases Jeddah	Estimated average Saudi Arabia
2011	?				
2012	?				
2013	30,052,518				
2014	30,916,994				
2015	31,717,667				
average	30,895,726			28	227.46
2017	33,099,147	4,076,000	12.31%		

WPR. World Population Review. http://worldpopulationreview.com/world-cities/jeddah-population/

Table: National estimates for Saudi Arabia

Population type	Year	Population size (av)	Fatal (WHO)	Non-fatal	Total cases
General	2013-2015	30,895,726	NA	227.46	NA

Limitations

There are only two publications, and one for these was on only one pesticide. There is no information on occupational UAPP.

44. Senegal

Extracted data

One study was eligible for data extraction. Tomenson and Matthews (9) is a survey of pesticide applicators and farmers commissioned by Syngenta Crop Protection among 2,431 users in eight countries. Tomenson and Matthews reported survey data of a representative sample of farmers and pesticide users from Senegal and pesticide poisoning incidents, serious moderate and minor. The total number of experiencing these in the past 12 months was 76 of 249 farmers and workers.

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

The farmer population was taken for 2006.

The percent prevalence was 30.522% * 1,198,448 = 365,790

Table: National estimates for Senegal

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General					
Farming/occupational	2006	1,198,448		365,790	
Children					

Limitations

The only data on pesticide applicator/farmer poisonings available was from Tomenson and Matthews, which was collected from 2006. No data were available on general or child population pesticide poisonings, and farmer/worker fatalities from pesticide poisonings data were not available.

45. Serbia

Extracted data

Publications extracted for synthesis: 1.

Vucinic et al. (98) reported data from the National Poison Control Center in Serbia. Non-fatal accidental poisonings data were available; the mortality data did not include information on whether the poisonings were intentional. The data were from 1998-2014, and the non-fatal poisoning rate was reported as not having diminished during those years. 410 cases were reported as being from organophosphate pesticide poisonings, with 8% of those cases due to accidental ingestion or inhalation.

Estimation of national figures

The average population of the last 5 years reported in the study (2010-2014) were used for the non-fatal poisonings' prevalence. The non-fatal poisonings cases were reported in Vucinic et al. 2018 as: 410 cases * 8% accidental, divided by 17 years = 2 cases per year for the time period. As the rate had not changed according to authors, this was used as the number of cases per year for the Serbian general population for non-fatal poisonings prevalence.

WHO Cause of Death data were available for the period 2011-2015.

Table: National estimates for Serbia

Population type	**Population**		**Fatal**	**Non-fatal**	**Total cases**
	Year	**Size**			
General	2010-2014, 2011-2015	7,184,259	0.8	2	2.8
Farming/occupational	2011-2015			NA	0
Children	2011-2015	1,022,008	0	NA	0

Limitations

The Vucinic study did not include data on poisonings from pesticides other than organophosphate insecticides, and did not report these data by year. It was inferred based on the paper's discussion that non-fatal poisoning cases could be averaged per year.

46. South Africa

Extracted data

Publications extracted for synthesis: 1.

Balme et al. (99) reported data on non-fatal and fatal pesticide poisonings of children from Red Cross War Memorial Children's Hospital, in Cape Town, South Africa.

Estimation of national figures

The catchment area described in Balme et al. (population of children aged 0-14) was 1,387,800. The eligible years of data were from 2006-2008, and the prevalence of non-fatal poisonings was taken as 0.00482778%. Balme et al. also reported 1 fatality per year, however, the WHO cause-of-death data were more recent and also based on national level reporting, so that was used for the national estimate.

The child population aged 0-14 from 2006-2008 was used to calculate the non-fatal pesticide poisonings estimate.

0.00482778% * 15,528,809 = 750

WHO Cause of Death data were available for South Africa for the period 2011-2015.

Table: National estimates for South Africa

Population type	Population		Fatal	Non-fatal	Total cases
	Year	**Size**			
General	2011-2015	53,771,984	16.6	NA	16.6
Farming/occupational				NA	
Children	2006-2008, 2011-2015	16,063,347	9.8	750	759.8

Limitations

It was not clear if the catchment area covered by the Balme et al. 2010 hospital in Cape Town was representative of other hospital areas, and the estimate was based only on the prevalence of poisoning from this Cape Town hospital. No non-fatal pesticide poisonings data were available for farmers/workers or the general population.

47. South Korea

Publications extracted for synthesis: 11.

Extracted data

Mortality data for the whole population are provided by three studies (100), (101), (102); mortality and morbidity figures by one study (103). Specific populations addressed were male farmers (104) as well as children (105). Results are from a nation-wide survey for male farmers (106–108) and a regional survey of farmers (109). Data from a sample of hospitals was provided by Moon et al. (110).

The study by Cha et al. (2014) is based on data of the national death registry and gives annually 455 fatalities (average 2006-2010). Kim et al. by the same data source give 51 fatalities annually (average 2009-2013). The difference is due to case identification. Both papers seem to make use of the ICD x-codes allowing differentiating the external causes of poisoning. However, Kim et al. report separately for “accidental” and “undetermined” whereas Cha et al. include “undetermined” along with others in “unintentional”. In a more recent paper (102) the authors provide data for accidental poisoning also separately showing 56 annual fatalities on the average 2008-2012.

Kim et al. (2012): Hospital discharges 2004-2006 provided rates of fatal and all APP per 100,000 populations. These were extrapolated by the authors from a representative sample of national hospitals. However, rates were not differentiated for accidental poisoning but the ratio accidental to all was provided as 15.5%. This share leads to a rate for fatal APP of 0.589/100,000 and 2.29 /100,000 for non-fatal.

Lee et al. (2014) analysed data of the National Health Insurance which covers the entire South Korean population. All patient medical utilization related to pesticide poisoning is expected to be included in the database. However, the paper was on pesticide poisoning for children less than 14 years of age for 2006-2009. On average, 307 non-fatal poisonings in addition to 1 fatal case occurred annually.

Lee et al. (2012) reported results from a cross-sectional survey which was designed to be representative for male farmers in South Korea in 2011. 1,985 respondents were asked whether any of 21 listed symptoms had been experienced within 48 hr of using pesticides. A total of 449 male farmers (23 %) reported experiencing at least one symptom, from which the authors calculated an annual figure of 209,512 occupational cases nation-wide. The same study was published by (106) and more specifically with respect to depression (107) and suicides (108).

Moon et al. (2016) analysed data of the “Injury In-depth Surveillance system”, which is conducted by the Korea Center for Disease Control and Prevention and include data of 20 emergency departments of hospitals in South Korea. In 2011-2014, an annual average of 150 non-fatal cases were reported. No information is given on the nation-wide coverage of included departments but authors state that their results are compatible to other South Korean studies.

Furthermore, mortality data were available from the WHO Cause of Death database, reporting 36 fatal accidental pesticide poisonings annually in the period 2011-2015.

Estimation of national figures

With respect to mortality, we use the WHO figures as the most recent period say to 36 annual cases for the general population and 0.2 for children. For non-fatal poisoning, we based our calculations for the general population on Kim et al. 2012 with a rate of 2.29/100,000. For farmers, non-fatal APP is based on the Lee et al. 2012 figures and assumed that the poisoning prevalence can be transferred to female farmers also. This gives an estimated annual non-fatal pesticide poisoning of farmers of 362,507 (23 % of 1,576,121 people employed in farming). Non-fatal APP for children is taken from Lee et al. 2014.

Assumed that cases of emergency department admissions are included in overall poisoning figures we do not consider the results by Moon et al. informative for our estimation.

Table: National estimates for South Korea

Population type	Population		Fatal	Non-fatal	Total cases
	Year	size			
General	2009-2013	49,885,466	36	1,142	1,178
Farming/occupational	2011	1,576,121		362,507	
Children	2006-2009 2011-2015	8,556,926	0.2	307	307.2

Limitations

Survey data considered were from male farmers only.

48. Spain

Extracted data

One study was eligible for data extraction. Tomenson and Matthews (9) is a survey of pesticide applicators and farmers commissioned by Syngenta Crop Protection among 2,431 users in eight countries. Tomenson and Matthews 2009 reported survey data from a representative sample of farmers and pesticide users in Spain who experienced pesticide poisoning incidents, serious, moderate and minor. The total number of farmers and users experiencing such incidents in the past 12 months was 75 of 250.

Estimation of national figures

Tomenson and Matthews reported 30% pesticide poisonings among pesticide users and the survey was conducted in 2006.

0.30*783,154 =234,946.2

WHO Cause of Death data were available from the time period 2011-2015.

Table: National estimates for Spain

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General	2011-2015	46,612,302	4.8		
Farming/occupational	2006, 2011-2015	783,154	0.4	234,946	
Children	2011-2015	6,923,469	0.2		

Limitations

Tomenson and Matthews 2009 was the only study with eligible data, but the sample was representative of pesticide users including farmers.

49. Taiwan

Extracted data

Publications extracted for synthesis: 2.

Chien et al. (111)

- Period of study = 1999-2008
- National data, applying to all pesticides
- Accidental and occupational
- 47.5% of hospitalisations were farm workers; 16.5% of deaths were occupational
- Average 59.4 deaths per year; incidence rate = 0.0002579%
- Average 633 not-fatal hospitalizations/year; incidence rate = 0.00274772%
- Source = Health Insurance Database from 1999 to 2008 released by the Taiwan National Health Research Institute (NHRI) in 2009
- Mortality rate fell from 0.8/100,000 in 2000, to 0.5 in 2008, so the data does not give a good representation of the situation for 2006-2008
- Hospitalization rate fell by 60% over the period
- Decisions was to review whether to use this in conjunction with other Taiwan studies
- Decision then taken that this data is too old

Chien et al. (112)

- Period of study = 2005-2007
- National figures, based on hospitalizations
- Average 470 not-fatal hospitalizations/ year; incidence rate = 0.00204348%

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

No occupational figures are provided, and no occupational incident rate can be estimated.

Table: National estimates for Taiwan

Population type	Year	Size	Fatal	Non-fatal	Total
General	2005-2007	22,927,215		470	

Population 2007 from worldometers

Limitations

The only data is for non-fatal hospitalisations and therefore is likely to be an underestimate, and the data is old.

50. Tanzania

Extracted data

Publications extracted for synthesis: 7.

da Silva et al. (113)

- Period of study = 2013
- 7 villages visited on Unguja Island, main island of Zanzibar Archipelago.
- Representative sample = 99 rice farmers
- Morbidity = 61% (any symptom)
- Data ok to extrapolate

Lekei et al. (114)

- Period of study = date not given
- Arumeru district in Arusha region, the villages of Uwiro, Olkung'- wado, Nguruma, Moivaro, Makisoro, Ambureni and Sing'isi comprising about 5% of all villages in Arumeru district. The selected villages were typical of vegetable and coffee growers of Arumeru district
- Representative sample = 121 vegetable farmers
- Morbidity = 93% (any symptom) (ever)
- Data ok to extrapolate

Manyilizu et al. (115)

- Period of study = 2015
- Arusha: two rural areas in northern Tanzania, namely Lake Eyasi and Ngarenanyuki in adjacent Karatu and Meru districts, respectively. The main crops produced for sale were tomatoes and onions in the Meru and Karatu districts
- Representative sample = 128 farmers
- Morbidity = 76.6% for most prevalent symptom, within the last 3 months
- Data ok to extrapolate

Tomenson and Matthews (9)

- Period of study = 2006
- Representative sample = 250 farmers and workers
- Morbidity = 74.8% any symptom over past 12 months
- Data ok to extrapolate

Lekei et al. (116)

- Period of study = 2006
- Part of the study reviewed hospital admission data for APP retrospectively (2000–2005) in 30 facilities in four regions of Tanzania (covering 30% of all hospital beds in Tanzania). A prospective follow-up over 12 months in 2006 focused on 10 facilities with the highest reporting of APP; data is extracted only for the 2006 follow-up
- The prospective study found an incidence rate of 4.04/100,000; mortality rate of 0.2/100,000
- 31% of known poisoning cases were accidental
- 10.2% of known poisoning cases were occupational

- 1.1% of cases were homicidal
- Morbidity = 0.000011579%
- Mortality = 0.000000175%
- Occupational morbidity = 0.0000041208%
- Occupational mortality = not known
- Homicidal mortality = 0.00000002%
- Data ok to extrapolate

Lekei et al. (117)

- Period of study = 2006
- This paper is a re-analysis of data from Lekei et al. 2014a and 2014b, which are more detailed and have been extracted
- Estimated high, median and low correction factors for underestimation were 71.4, 22.2 and 9.6, respectively, to include occupational APP cases occurring in the community that are not detected from routine facility-based surveillance
- The underlying rate of occupational APP based on the lower boundary of the correction factor for under-estimation would be 11.3 to 37.6 cases/1,000,000 and based on the upper boundary of the correction factor, rises to 84.3 to 280.0 cases/1,000, 000. So, the range = 11.3 to 280/1,000,000
- Depending on the choice of scenario and under-reporting correction factor used, occupational APP could comprise from 52.2 to 96% of all APP cases
- Correction factors for underestimation should be discussed in final paper

Lekei et al. (118)

- Period of study = 2006
- Children only
- 10 health facilities in 4 districts; same data as used in the prospective part of Lekei et al. 2014b but focussing only on children
- Sample size = 3,285,298
- 31 cases: accidental = 26, occupational = 4, homicide = 1
- Morbidity = 0.00094360%
- Paper states a "population-based incidence rate" in northern Tanzania
- Data ok to extrapolate

Estimation of national figures

a) synthesis of occupational studies

The four studies farmers and workers were averaged without weighting to arrive at a percentage occupational morbidity of 76.35%. The hospital-based studies were synthesised separately.

Study	Year	Sample	Popul.	Morbidity	Symptom range	Time covered	Extrap
da Silva 2016	2013	99	farmers	61%	any	?	+
Lekei et al. 2014a	n.d	121	farmers	93%	any	ever	+
Manyilizu 2017	2015	251	farmers	76.6%	highest	?	+
Tomenson 2009	2006	250	farmers & workers	74.8%	any	last 12 months	+
	average		*farmers & workers*	*76.35%*			

b) synthesis of papers on hospital surveillance

Study	Year	Child morbidity	Morbidity	Mortality	Occupational morbidity	Homicide	Extrap
Lekei et al. 2014b	2006		0.00000017%	0.000000175	0.0000041208%	0.00000002%	+
Lekei et al. 2016	2006			?			+
Lekei et al. 2017	2006	0.00094360%		?			+
	average	*0.00094360%*	*0.00000017%*	*?*		*0.00000002%*	

WHO Cause of Death data: no mortality data were available.

Summary of national estimates

Table: National estimates for Tanzania

Population type	Year	Population size	Fatal	Non-fatal	Total cases
General	2006	40,634,948	7.1	470	
Farming/occupational	2013-2015	15,940,378		12,170,479	
Children	2006	18,423,465		173	

Limitations

No mortality data were available.

51. Thailand

Extracted data

Publications extracted for synthesis: 5.

Kachaiyaphum et al. (119)

- Period of study = 2007, Oct-Dec
- Chatturat District, Chaiyaphum Province, 342 km northeast of Bangkok, where chilli is a major product; 5 of the 9 sub-districts were selected for study, 70 of the 75 villages (5 villages had no chilli growing), 5 households from each village
- Estimated population of Chatturat District = 75,948 people living in 22,401 households
- Representative sample = 350 chilli farmers and workers
- Morbidity = 38% (most prevalent symptom)
- Data ok to extrapolate

Kongtip et al. (120)

- Period of study: August 2013 to February 2014
- Provinces of Nakorn Ratchasima in the northeast, Phisanulok province in the lower north, and Payao province in upper north of Thailand.
- 11.4 million people (38% of population) work in agriculture in Thailand
- Representative sample = 424 vegetable farmers (mostly) and workers (60% women), representing 5 farm types: rice, vegetable, flower, rice/vegetable, and flower/vegetable
- Morbidity = 34.2% (most prevalent symptom) – last 3 months
- Data ok to extrapolate

Sapbamrer and Nata (121)

- Period of study: August and Oct 2012
- Bam Tom subdistrict, which is located close to Kwan Phayao Lake, northern Thailand
- Representative sample = 182 rice farmers within 1 month prior to interview
- Morbidity = 42.9% (most prevalent symptom)
- Data ok to extrapolate

Sapbamrer et al. (122)

- Period of study: 2014, Sept-Oct
- Phayao Province, Northern Thailand
- Sample = 84 farmers
- Morbidity = 29% (most prevalent symptom)
- Data ok to extrapolate

Thetkathuek and Jaidee (123)

- Period of study: date not given
- Sample = 891 migrant agricultural workers from 78 fruit farms who self-reported pesticide exposure and whose employers reported OP and/or carbamate use on farm
- Morbidity = 87.88%, 74.3% with more than one symptom
- Not representative, not for extrapolation

WHO Cause of Death data

For 2012-2016: 39 fatalities, including 12 children, = 7.8/yr (general), 2.4 (child).

Estimation of national figures

Study	Year	Sample	Population	Morbidity	Symptom range	Time covered	Extrapol.
Kachaiyaphum 2010	2007	350	farmers & workers	38%	highest	?	+
Kongtip 2018	2013-14	424	farmers & workers	34.2%	highest	last 3 months	+
Sapbamrer & Nata 2014	2012	542	farmers	42.9%	highest	?	+
Sapbamrer et al. 2017	2014	84	farmers	29%	highest	?	+
	average		*farmers & workers*	*36.03%*			

The four studies on farmers and workers were averaged without weighting to arrive at a percentage occupational morbidity of 36.03%. The additional study of immigrant fruit farm workers who were exposed to OPs and/or carbamates, although not included here, should be noted because it indicates very high APP in at least one sector of the Thai agricultural economy.

The 4 studies span 2007-2014, and WHO Cause of Death data on mortality were available for 2012-2016, so the latter time frame is used for the estimates.

Table: National estimates for Thailand

Population	Year	Population	Fatal	Non-fatal	Total cases
General	20012-2016	68,384,986	7.8		
Farming/occupational	2012-2016	14,170,704		5,105,704	
Children	2012- 2016	12,473,536	2.4		

Limitations

All studies show morbidity only for the highest prevalence symptom, none report prevalence with any symptom.

52. Uganda

Extracted data

Publications extracted for synthesis: 4.

Two studies made use of hospital admission data (124) (125) and two reported on cross-sectional surveys of farmers (126) (127).

The study by Ssemugabo et al. (2017) was conducted in 5 hospitals in Kampala. The hospitals were selected for being the largest within the city and because treatment of a large number of pesticide poisoning patients. The hospitals are a mix of a national referral hospital, not-for profit, or private hospitals. According to the authors Kampala has a population of about 1,516,210 of the country's 34.8 million people. Over the period of 2010-2014 the paper reports an annual average of 16 non-fatal cases.

Pedersen et al. (2017) reports on an urban and a rural study. The urban study is the same as published by Ssemugabo et al. The rural study was carried out in the districts of Wakiso and Pallisa and included data from 22 of 61 Health Centers. Wakiso has a population of 2 million, Pallisa of 387,000. The data were collected by clinical staff who had received training in pesticide diagnosis and treatment of poisonings. Over the period 2013- 2016 annually 15 cases were reported. The mortality ratio was given as 3.8 % but intentional/unintentional not differentiated.

Clausen et al. (2017): Results of a survey of 114 small-scale farmers (cotton as main product) after an IPM intervention in 2012 in Wakiso and Pallisa - the same districts as mentioned above – were published by (127). Symptoms caused by pesticides were assessed by self-reports. Thirteen acute symptoms caused by pesticide exposure were read out loud, and the farmers affirmed whether they had experienced the symptom working with pesticides within the last 6 months. The authors report that 65 farmers (57%) in total had experienced at least 3 symptoms.

Okonya and Kroschel (2015): Results of a survey of 204 potato farmers from 6 sub-counties are published by (126). No study year was reported but likely it took place in 2013. 157 respondents (75%) reported having felt sick after pesticide application.

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

The hospital-based studies cannot be used for extrapolation because the papers do not give information on the total number of hospitals in Kampala, or the rural districts, or the coverage by the selected hospitals, or the catchment areas.

In order to estimate the nation-wide number of non-fatal pesticide poisoning we averaged the results from the farmer surveys (57% + 75%) and extrapolated to a farmer & agricultural workers population of 9,021,117 (average from 2012-2013, see World Bank database) resulting in an annual number of 5,953,937 acute occupational pesticide poisonings.

Table: National estimates for Uganda

Population type	Population		Fatal	Non-fatal	Total cases
	Year	size			
General					
Farming/occupational	2012-2013	9,021,117		5,953,937	
children					

Limitations

Hospital data could not be used, no information on general population.

53. UK

Extracted data

Publications extracted for synthesis: 2.

Perry et al. (128) reported data from the UK National Poisons Information Service from 2004-2012. The data included mortality and morbidity cases, and the data taken for extraction were based on 2010-2013 for acute unintentional poisonings: 6789 unintentional acute pesticide exposures over 2004-2013; 3727 total exposures for 3 years from 2010-2013, "a minimum estimated incidence of pesticide exposure requiring health care contact". 87% of cases were acute unintentional = 3727 x 87% = 3242 = 1081/yr. Fatal cases were reported from 2004-2013 at a rate of 1 per year of unintentional poisonings for adults.

Solomon et al. (129) reported data from three rural areas in England and Wales. The data were self-reported by farmers and workers, with non-fatal cases reported as those who had ever used pesticides who experienced symptoms within 48 hours of use. The sample size was 4,108 farmers and workers, and 23% were reported as having experienced symptoms (944.84 cases).

Estimation of national figures

In the data extraction, Perry et al. data on fatalities were described as possible lower boundary data (adults, 1 case per year 2004-2013). However, the cases reported by the WHO cause-of-death database were a lower prevalence of 0.4 cases per year from 2011-2015.

For acute unintentional exposures of children, Perry et al. reported that 54.1% of the cases were involving children ≤ 12 years of age. “More acute unintentional exposures involved children (≤12 years) than adults: 3,674 (54.1%) exposures were in children, 3,058 (45.0%) exposures were in adults (57 unknown [0.8%]).” So, we calculated the children unintentional poisonings based on the general populations estimate, taking 54.1% of the general population estimate, and we can take this as a lower boundary estimate for accidental pesticide poisonings of children: 0.541* 1,081 non-fatal pesticide poisonings in general population = 584.8 children cases <=12 years**.**

Solomon et al. data were used for national estimates based on the 2006 farmer and worker population.

WHO Cause of Death data were available for UK, for the period 2011-2015.

Table: National estimates for UK

Population type	Population		Fatal	Non-fatal	Total cases
	Year	Size			
General	2011-2015	64,165,893	0.4	1,081	1,081.4
Farming/occupational	2006[S], 2011-2015	397,175	0	91,350	91,350
children	2011-2015	11,268,488	0	584.8	584.8

Limitations

Solomon et al. 2007 reported survey data on a lifetime prevalence of pesticide exposure, so these data must include pre-2006 data. The lifetime prevalence varied significantly by area surveyed. These data were used to make an estimate based on the year 2006 farmer/worker population for non-fatal pesticide poisonings.

Perry et al. 2014 data were from poison centres only in the UK and were thus representing a lower boundary estimate for the general and child populations. The estimate of accidental poisonings of children was based on Perry's reported figure of 54.1% of cases involving children < or = age 12. The WHO cause-of-death data on children population includes children ages 0-14.

54. USA

Extracted data

Publications extracted for synthesis: 25.

For reports that were issued by the same association (such as the American Association of Poison Control Centers), the most recent 5 years of data were used.

Groups or agencies collecting data: There is no national mechanism for reporting all of the pesticide poisonings in the US. The US EPA collects data on pesticide poisonings but does not make this information publicly accessible. SENSOR has 12 participating states, with some states joining after the program was initiated. The SENSOR program is a group of several US states, that have agreed to submit pesticide poisoning data to the US Centers for Disease Control. There are 13 SENSOR states, but different studies report different numbers of participating states, depending on the timeframe covered or other factors affecting the data collected. In addition, the California Department of Pesticide Regulation database on poisonings, including drift incidents and resultant poisonings, is detailed and published online, and in some of the studies was used as a source for data in addition to SENSOR data—California is a SENSOR state. National Pesticide Information Center collects data, as do the American Association of Poison Control Centers.

National Level

Kamboj et al. 2018 (130) reported data on ocular exposure for the entire US population (poison control centres), from 2000-2016 but for our purposes we should extract 2012-2016 data. The number of moderate and major cases for 2012-2016 were 5,540 or 1,108 cases per year * 4.23%= 46.8684 moderate/major cases per year for that period. It was not possible to track or calculate "minor" cases reported in this study – there was a figure of 51.1% "minor cases" for all compounds given, but it was questionable whether this can be used for pesticides. Pesticides moderate and major outcomes = 4.23% of ocular exposure for the entire period of 2000-2016. We made the assumption that the same percentage applied to the period of time we used for data analysis.

Langley and Mort 2012 (131) reported data on the entire US population, 2006-2010. These data included mortality data, and the population for the time period was 292,500,000 with 22 fatalities per year and 41,132 non-fatal cases per year. Various data sources including poison control centres and CDC.

Yin 2011 (132) reported national level data from 2000-2008 for children less than 7 years of age, with 0 fatalities reported and 45 non-fatal cases of pesticide poisoning reported for malicious pesticide poisonings only. These data were not reported as annual cases, but the time period from 2006-2008 can be taken with the assumption that the same number of cases occurred per year. The US population of children from 2006-2008 would be taken.

NPIC – 2013-2017 data

NPIC receives calls and reports these data to EPA. They are open Monday-Friday, for 4 hours per day. They are not as well-known as poison control centers. There is no centralized national database that allows us to access poisonings data in the US—NPIC is the only source that is specifically on pesticides. We included the reports from 2013-2017 (133–137)

NPIC 2013 reported national level data for the US from June 1 2013-2/14 2013, extracting unintentional pesticide poisonings. 1 fatality and 1,019 illnesses occurred that year.

NPIC 2014 reported national level data for the US in 2014, and reported 0 fatalities and 852 illnesses that year.

NPIC 2015 reported national level data for the US from 2015 and reported 0 fatalities and 858 illnesses that year.

NPIC 2016 reported national level data for the US from 2016, 0 fatalities and 987 illnesses that year.

NPIC 2017 reported national level data for the US from 2017, 0 fatalities and 899 illnesses that year.

American Association of Poison Control Centers reports- 6 years of data, 2012-2017

Gummin et al. 2017 (138) reported American Association of Poison Control Centers data from 2016. The population was the entire US population (327,000,000) and the non-fatal cases per year were 72,144. The prevalence for non-fatal poisonings was 0.02206239%.

Gummin et al. 2018 (139) reported American Association of Poison Control Centers data from 2017.

The population was the entire US population (330,400,000) and the non-fatal cases per year were 72,871. The prevalence for non-fatal poisonings was 0.02205539%.

The years 2013- 2016 were published by (140–143).

Mowry et al. 2016 reported fatal and non-fatal national data from the American Association of Poison Control Centers, however fatalities data were not extracted because the unintentional poisonings cases were not reported out separately. The non-fatal unintentional poisoning cases = 73,352 cases in 2015 for the US population that year.

Mowry et al. 2015 reported fatal and non-fatal national data from the American Association of Poison Control Centers, however fatalities data were not extracted because the unintentional poisonings cases were not reported out separately. The non-fatal unintentional poisoning cases = 72,590 cases in 2014 for the US population that year.

Mowry et al. 2014 reported fatal and non-fatal national data from the American Association of Poison Control Centers, however fatalities data were not extracted because the unintentional poisonings cases were not reported out separately. The non-fatal unintentional poisoning cases = 74,215 cases in 2013 for the US population that year.

Mowry et al. 2013 reported fatal and non-fatal national data from the American Association of Poison Control Centers, however fatalities data were not extracted because the unintentional poisonings cases were not reported out separately. The non-fatal unintentional poisoning cases = 77,690 cases in 2012 for the US population that year.

WHO Cause of Death data were available from 2011-2015 for the United States, with 5 cases/year reported from the general population for that time period, 0 reported for farmers, and 0 reported for children.

Regional Level

Calvert et al. 2016 (144) reported 2007-2011 data for occupational pesticide poisonings in the US based on data from 12 states participating in the SENSOR program. Two of the states did not provide data for the entire time period (Nebraska: 2011 only; New Mexico: 2007-2008 only). The entire population 2007-2011 for full time equivalents estimates was 296,764,512, with a 0.9 incidence rate. Occupational poisonings prevalence was 521 poisonings/year and 0.4 deaths/year. The study also reported separately the farmer/worker population for the states was 4,486,533 with 833 poisonings.

Higgins et al. 2016 (145) reported data from the state of North Carolina only, from 2007-2012. This state participates in SENSOR programme, and perhaps it is redundant. 39 cases non-fatal poisonings; 0 deaths. The population was occupational with two of the major industries for that population being agriculture and structural pesticide use; non-occupational exposures were also reported but these probably included suicides so the data were not extracted.

Hudson et al. 2014 (146) reported 2006-2008 data for 11 SENSOR states on non-fatal occupational pesticide poisonings with pyrethrin and pyrethroid pesticides. They reported 742 cases per year from 60,627,451 full time equivalents, calculated by the study scientists.

Kasner et al. 2012 (147) reported data on farmers and farmworkers from the period 2000-2007. The data extracted were farmworkers only, for 2006-2007. The non-fatal cases per year were 228, out of a population of 325,007. No fatal data reported. These data were from SENSOR and CA DPR.

Lee et al. 2010 (148) reported non-fatal exposures to fipronil, an individual pesticide, and most of the data were pre-2006. They reported 26 exposures/year for 2006-2007 period, in sensor states for a mixed population. There are 12 SENSOR states but Arizonz was excluded from analyses because so few cases of poisoning were reported: CA, FL, IA, LA,MI,NM,NY,NC,OR,TX, WA (AZ excluded, IA: 2006-2007; NM 2005-2007; NC 2007 only).

Lee et al. 2011 (149) reported drift cases, both occupational and nonoccupational non-fatal cases. The population was 124,500,00 with 236 total cases for 2006 (prevalence = 0.0001896%), to be extrapolated to the whole US population. Data from 11 SENSOR states included here in this study, and California Department of Pesticide Regulation. Prevalence was calculated based on drift cases for 11 states in 2006 and extrapolated to the entire US population for national estimate. Included because drift related illness data are very rare and it is likely that these data are infrequently reported to poison control or NPIC (though it is possible that some reports have been made to poison control or NPIC). Prevalence* US population 2006: 0.000189600% * 298,379,912 = 565.7

Liu et al. 2018 (150) reported poisonings from total release foggers, from 2007-2015. The data from 2013-2015 were reported for a 10,000,000 population (10 SENSOR states) and taken as the prevalence, 0.00027900%, for the region (the data used were from 2011-2015).

Namulanda et al. 2016 (151) reported acute nonoccupational pesticide poisonings from 7 states, 1159 of a population of 72,280,376 participating in the SENSOR program from 2007-2011. Prevalence calculated as 0.00160348% for the 7 participating states (FL, LA,MI,NC,NY,OR, WA).

Spiller et al. 2013 (152) reported non-fatal poisonings of children under 6 years old from 2006-2010 for 5 US states: KY, LA,NC, OH, TX. The population was reported in the study as 54,900,000 and number of cases per year was 8,005. These data were from poison centres only in those states.

Trueblood et al. 2016 (153) This paper had data on TX population poisonings of children $\leq$ 19 years of age, 2009-2013 period. 0.4 deaths per year, and 12 non-fatal cases per year for that time period with catchment area of 7,621,714 and included only hospitalizations.

Estimation of national figures

For the data synthesis, there were many studies contributing to the data. For national estimates, preference was given to studies or reports that had national level data. The national estimates did not involve averaging the prevalence because a decision was taken to rely on the American Association of Poison Control Centers dataset (AAPCC). This dataset was the largest and most comprehensive on non-fatal poisoning cases and so was the best option for national reports on pesticide poisonings in the US.

The papers and time periods covered for national estimates where data were ready to take are listed below and in a summary table. These covered the general population.

Table: Contributing studies for general population

Population type	Study	Population		Fatal	Non-fatal	Total cases
		Year	Size			
General	AAPCC	2012	313,993,272	Not used	77,690	
		2013	316,234,505		74,215	
		2014	318,622,525		72,590	
		2015	321,039,839		73,352	
		2016*	327,000,000		72,144	
		2017*	330,400,000		72,871	
	Combined AAPCC	2012-2017	321,215,024		73,810	73,810
	NPIC	2013	316,234,505	1	1,019	
		2014	318,622,525	0	852	
		2015	321,039,839	0	858	
		2016*	327,000,000	0	987	
		2017*	330,400,000	0	899	
	Combined NPIC	2013-2017	322,659,374	0.2	923	923.2
	WHO Cause of Death	2011-2015	316306884.2	5	NA	5
	Kamboj et al. 2018	2012-2016	318659215.2	NA	1,108**	
	Langley and Mort 2012	2006-2010	292,500,000	22	41,132	

*For 2016 and 2017 the US population used was the number reported in AAPCC and NPIC studies
** ocular exposures, Kamboj et al. 2018

Some studies allowed for extrapolation to national estimates of the occupational poisonings counted in the US, and children. We estimated the number of poisonings by multiplying the prevalence by the respective population. For fatalities, the WHO Cause of Death data were a more recent source.

1. We averaged the occupational non-fatal prevalence of the 3 studies in the following table. We excluded Hudson et al. because only specific active ingredients were studied.
2. For children we did not take into account the study of Trueblood et al. as this study only had figures on hospitalizations.

Table: Contributing studies for extrapolations from regional data

Population type	**Study**	**Population**		**Fatal**	**Non-fatal**	**Total cases**	**Prevalence**
		Year	**Study population size**				
Occupational, SENSOR states	Calvert et al. 2016	2007-2011	897,306	0.4	166	166.4	0.0185 % Non-fatal; 0.00000013479% fatal
Occupational, North Carolina only	Higgins et al. 2016	2007-2012	74,285*	0	39	39	0.0525005%
Farmer/farmworkers, SENSOR states	Kasner et al. 2012	2006-2007	325,007	NA	228	228	0.0701523%
Average occupational prevalence		*2006-2012*		*0- *****			*0.047 % Non-fatal; 0.0000446 % fatal*
Children under 6, poison control, 5 US states	Spiller et al. 2013	2006-2010	54,900,000	NA	8,005	8,005	0.0145811%

*US Department of Agriculture National Agricultural Statistical Service data – average of the NC farmer/farmworker population from 2007 & 2011

** WHO cause-of-death data were from 2011-2015

Table: Summary of national estimates for USA

Population	**Study**	**Population**		**Fatal**	**Non-fatal**	**Total cases**
		Year	**Size**			
General	AAPCC/WHO COD 2011-2015	2011-2017*	319,996,783	5	73,810	73,815
Farming/occupational	Calvert 2011, Higgins 2016, Kasner 2012; WHO COD 2011-2015	2006--2015	2,294,329	0	1078	1078
Children up to age 14	Spiller 2013, , WHO COD 2011-2015	2006-2015	62,123,344	0	9,058	9,058

*For 2016 and 2017 the US population used was the number reported in AAPCC and NPIC studies; the rest are WHO figures on the US population

The general population estimate taken was from the AAPCC data—these reports have the biggest and most comprehensive dataset. The other national level studies focused on certain types of cases, such as individual pesticides only, or ocular poisonings in one study.

The estimates for non-fatal poisonings for the farmer/farmworker and child population were the result of averaging the prevalence from studies of the relevant population and extrapolating to the entire US population. World Bank data were used for the farmer/farmworker population, child population, and for the general US population except for the 2016 and 2017 US general population, which was reported in the AAPCC reports.

For the farming/occupational estimate, it was possible to separate out the farmer/farmworker population using data from three studies that specifically contained farmer/farmworker numbers.

Limitations

Full time equivalents for workers: in Calvert et al. 2016, one FTE = 2000 hours worked, which represented 250 days of 8-hour days. We are not sure how realistic this estimate is, however, it was used by study authors and we relied on it for calculations for this study. There is evidence that agricultural workers put in far more than 8 hour days during certain times of the growing season, and it is possible that this FTE estimate is therefore an underestimation.

The occupational data were used to extrapolate for the farmer/farmworker population reported by World Bank; however, one limitation is that the occupational poisonings data includes workers who are not necessarily working primarily in agriculture. In addition, the estimated number of farmworkers in the US varies depending on the source, reporting may not be totally reliable due to some percentage of that workforce being undocumented—fears of being persecuted due to immigration status can affect participation, and thus reporting, to the US census. Current estimates of the farmworker population alone are approximately 2 million, the total number of agricultural workers and farmers estimated by World Bank is over 2 million for the US.

The catchment area data are the only US data on non-fatal poisonings for occupational and children poisonings. In some of the studies, only one state was used for data, yet the prevalence from all of these studies were averaged in order to extrapolate for an estimate of poisonings across the entire US population. We also only had three studies focusing on poisonings of children, one on children under the age of 6, one on malicious poisonings of children under age 7, and one for children at or less than the age of 19 years. In addition, the World Bank data set we are using was set for a child population for the US as aged 0-14 years. Though data on children past the age of 14 can be found in the US census, we used the World Bank data here because we are using it for every other country in order to estimate the child population.

Not all of the US states are the same with regards to agriculture, and so some regions of the US use different or more diverse pesticide regimens when, for instance, growing specialty crops such as fruits and nuts. Therefore extrapolating for occupational related pesticide poisonings to the entire country may also introduce some inaccuracies.

55. Venezuela

Extracted data

Publications extracted for synthesis: 1.

Gomez and Cáceres 2010 (154) sampled 50 workers fumigating against dengue fever pest using organophosphate pesticides in the Aragua state of Venezuela in 2008. The sample was a simple sample or not stated, taken from the 78 individuals working in the dengue control program in Aragua state. The study reported 62% of the 50 workers were affected, which was calculated as 31 individuals. No fatalities were reported in this study, as it was a survey. The workers were also tested for acetylcholinesterase levels, of which 38% had altered Ache.

Estimation of national figures

We did not find any data on pesticide applicators working on dengue control. We took the entire agricultural worker population as the group from which poisoned workers are calculated.

62% of the worker population were affected according to Gomez et al. 2010, the 2008 agricultural worker population was 1,007,399.

$$0.62 * 1{,}007{,}399 = 624587.483$$

WHO Cause of Death data were available for Venezuela from 2009-2013.

Table: National estimates for Venezuela

Population type	**Population**		**Fatal**	**Non-fatal**	**Total cases**
	Year	**Size**			
General	2009-2013	29,457,915	17.6		
Farming/occupational	2008 [S]	1,007,399		624587.483	
	2009-2013	1,040,615	0.6		
Combined farming/occupational	2008,2009-2013	1,024,007	0.6	624587.483	624588
Children	2009-2013	8,669,169	4.8		

Limitations

The estimate for occupational/farming poisonings is problematic, as the survey was of dengue control pesticide applicators working only with organophosphate pesticides. The individuals surveyed in the Gomez et al. 2010 study were workers, but it was not clear whether these applicators also worked in agriculture. The estimate used the data on the agricultural farmer/worker population, which may not reflect the number of workers actually using pesticides in general. It is likely that organophosphate pesticide use incurs greater numbers of poisonings, however, this is not certain and at any rate we do not have better data on the pesticide use situation in Venezuela.

In addition, we have no data on non-fatal poisonings of the general or child population.

56. Vietnam

Extracted data

Publications extracted for synthesis: 4.

Thong & Phong (155)

- Period of study: date not given
- The study was conducted in 3 communes Vinh Hanh, Vinh Binh and Vinh An Chau in the Thanh district of An Giang, in the Mekong Delta which covers 30,739 hectares, of which 97.4% is devoted to rice cultivation
- Representative Sample = 45 workers (pesticide applicators)

- Morbidity = 60% (most prevalent symptom)
- Data ok to extrapolate

Schreinemachers et al. (22)
- Period of study: 2015
- Representative sample = 300 vegetable farmers growing yard-long beans and leaf mustard
- Morbidity = 30% (most prevalent symptom)
- Data ok to extrapolate

FAO (21)
- Period of study: 2008
- Study areas = Hanoi and Thai Binh
- Sample = 251 farmers
- Morbidity = 55.38% (any symptom)
- Data ok to extrapolate

Rengam et al. (8)
- Period of study: 2015-2017
- PANAP, in partnership with CGFED, worked with the women farmers from Hai Hau, a rural district in Nam Dinh Province (rice and vegetables). Farmers from Ao Sen and Dong Cham Villages in Thai Nguyen province were also engaged, through SRD.
- Purposive sample = 534 farmers (58.61% women)
- Morbidity = 84% (any symptom)
- Data ok to extrapolate

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Study	**Year**	**Sample**	**Popul.**	**Morbid.**	**Symptom range**	**Time covered**	**Extrapolated**
Thong & Phong 2011	?	45	workers	60%	highest	?	+
Schreinemachers 2017	2015	300	farmers	30%	highest	?	+
FAO 2013	2008	251	farmers	55.38%	any	?	+
Rengam 2018	2015-17	534	farmers	84%	any	?	+
	average		*farmers & workers*	*57.35%*			

The four studies on farmers and workers were averaged without weighting to arrive at a percentage occupational morbidity of 57.35%.

Table: National estimates for Vietnam

Population	Year (average)	Population size (WB)	Fatal	Non-fatal (estimated)	Total cases
general	2015-2016	94,070,320	?		
farming/occupational	2015-2016	23,803,488	?	13,651,300	
child	2015-2016	21,716,369	?		

Limitations

Two studies show morbidity only for the highest prevalence symptom, and two with any symptom.

57. Zambia

Extracted data

Publications extracted for synthesis: 1.

Z'gambo et al. (156)

- Period of study: 2012
- 2 hospitals in Lusaka - retrospective extraction of data on acute poisoning cases from records at Levy Mwanawasa General Hospital (LMGH) and the University Teaching Hospital
- Morbidity = 61 cases
- Lusaka district has a total population of 1.7 million
- Lusaka district has 3 tertiary hospitals, 1 secondary hospital, 9 primary hospitals, 170 urban health centres and 11 "health post"
- Unclear catchment area
- Data not ok to extrapolate

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

No summary or national estimates can be given

Limitations

There was only one study of hospital admissions, drawing on an unclear catchment area, so not suitable for extrapolation. No data on mortality.

58. Zimbabwe

Extracted data

Publications extracted for synthesis: 1.

Magauzi et al. (157)

- Period of study = 2006
- Kwekwe district
- Representative sample = 246 workers
- Morbidity = 45.1% (any symptom, ever)
- Data ok to extrapolate

WHO Cause of Death data: no mortality data were available.

Estimation of national figures

Table: National estimates for Zimbabwe

Population type	Year	Population size	Fatal	Non-fatal (estimated)	Total cases
farming/occupational	2006	4,400,493	?	1,984,622	

Limitations

There was only one study, and it was based on recall. There were no data on mortality.

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